Water Spectrum

issues·choices·actions

DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

Vol. 5, No. 1, 1973

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Comments on topics in this publication are invited. Send to:
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Two years ago, our summer issue announced the Corps commitment, in cooperation with the Environmental Protection Agency, to direct its planning and engineering capabilities to eliminate water quality abuses—particularly to develop alternatives to the practice of discharging partially treated wastewater and sludge into rivers, lakes and the oceans. The following article strongly advocates natural recycling of sludges resulting from municipal wastewater treatment. The recycling alternative is one of several being examined in the Corps wastewater management studies, so that communities may have a meaningful choice in deciding how to cope with their sludge management problems.

High yield corn grows on the ridges between furrows fertilized by applications of digested sludge.

COVER: Bolinas Lagoon is a protected estuarine habitat north of San Francisco that displays land and water uses of unique concern in the coastal zone. For a story on new national and State efforts in coastal zone management, see page 32.

PHOTO CREDITS

Picture on front cover—NASA aerial imagery
Picture on Page 10—Hammond Times. Picture on page 11—Chicago Today. Picture on page 25—Washington Post. Pictures on pages 18, 19, 22, 23, 37 and 40—Bureau of Reclamation, Department of the Interior.

Compunctions are growing against having partially treated sludge dumped into streams and oceans. Incineration that meets new emission standards will cost more than recycling to land. Burning, dumping or permanent lagooning is sheer waste of a valuable resource.

by T. D. Hinesly
Scientific Advisor, Civil Functions
Office of the Undersecretary of the Army

Despite the intensity of current feelings on the subject, the near future will surely witness the gradual reuse of wastewater nutrients on the land in preference to continuing disposal into flowing water and landfills. Impetus for such a drastic change in attitude will form out of an evolving realization that standard disposal practices waste money, natural resources and energy as well as wasting the waste material.

Nothing is really new or unusual in the concept of returning these valuable nutrients to the soil. Since the beginnings of civilization raw waste has been a valid source of fertilizer for food crops. The rise of western man and his increasing sophistication—somewhat misguided—fostered a revulsion against recycling odorous waste material back to the land. Accompanying this civilizing process was a propensity to substitute water disposal methods over land recycling.

The growing public demand for clean water that is now upon us is but a fraction of the clamor that will be raised as the technological facts of pollution become clearer. We can expect the sanction of ever stricter regulations outlining more stringent methods for removal of waste materials from the effluents of municipal sewage treatment plants. Once removed, these waste products must either be used in a beneficial way or disposed of in a manner that will prevent them from reappearing as an environmental pollutant.

In the recent past there was little public attention paid to disposal methods. This was not just a result of lack of respect for the environment; but also because our water quality standards were relatively low and the volume of waste treatment plant residues, called sludge, was correspondingly less than the volume we must expect in the future.

Furthermore, the supply of land for use as landfills and sludge lagoons could formerly be obtained quite close to treatment plants at a still reasonable cost. This is no longer true. Thus, until recently, sludge handling problems have been ignored in deference to the development of advanced wastewater treatment technology.

We are returning to the recycling concept that municipal sludge, if properly stabilized, can be utilized as both a reconditioner of barren soils and a fertilizer of crops. Before sludge can be applied to the land, however, we need to exercise caution in the selection of each sludge utilization site. We also need to modify each site, as required, to ensure that the sludge constituents are not eroded away from the point of application. We need to adjust application rates to specific crop requirements for soluble nitrogen demand. Last, we need to establish sound crop and soil management practices.

Sludge, once stabilized, is too valuable a resource to dump into oceans, to burn or to permanently lagoon. The problem in the past has been that attempts to use various *unstabilized* sludges as a source of fertilizer elements usually ended in failure because of severe odor and fly breeding problems.

At one time waste disposal was a very simple matter. About all that was needed was a collection system that would carry the waste by gravity to a river or creek which would then transport the material away from the immediate vicinity of the community. Eventually, sewage volumes increased as a result of expanding population and industrial growth, and it became obvious that the assimilating capacities of many streams often used as a source of water supply were being exceeded.

Often the first attempt to reduce the pollutant loads delivered to streams was simply to provide equipment to screen and settle out a major portion of the solids. However, the effluent from the primary treatment operation still contained some suspended solids and practically all the soluble organic and inorganic material contained in the original sewage. A further reduction in the amount of pollutants discharged into the water was accomplished by a process of utilizing microorganisms to remove the soluble organics.

This process is the one most often employed. Large supplies of air are pumped through the effluent, causing aeration that enable aerobic microorganisms, or bacteria present in the oxygen, to oxidize some of the soluble organics in the effluent. Most of the soluble organics are oxidized into carbon dioxide and water. Meanwhile, some of the organic components are utilized in the production of new microbial cellular materials.

As each mass of microbial cellular material is settled out in clarification tanks, some is wasted and some is returned to the aeration tanks. This wasted portion is often referred to as *waste activated sludge*. A word of caution here. Sludges collected during both primary and secondary treatment are still raw solids and should never be considered for use as a fertilizer or soil amendment

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Dr. Hinesly, a soil ecologist, is on leave for one year from the University of Illinois.

without further treatment which would stabilize these solids against rapid degradation after being applied to soil surfaces. *Attempts to use these raw solids as fertilizer elements will generate noxious results.*

On a smaller scale, some primary effluents have been given secondary treatment by means of carbon columns which filter out the remaining suspended solids and adsorb much of the soluble organic materials. While smaller masses of sludges are produced by this physical-chemical treatment compared to the microbial (waste activated) processes described above, they are still raw solids and cannot be stored or utilized on land without further stabilization of their organic constituents.

High temperatures applied to the carbon filters regenerates their adsorbing capacity by oxidizing the previously adsorbed soluble organics. Thus, a pollution problem still exists because *air* becomes the ultimate sink for a large part of the organic materials that are first adsorbed in the carbon columns, then decomposed by heating.

Sludges accumulated at waste treatment plants serving large coastal cities have usually been barged and dumped into oceans with little or no treatment. But the long term effects on marine life of non-biodegradable and biodegradable resistant toxic materials contained in all sludges are to a large extent unknown. Thus, a complete ban on the dumping of sludges in oceans could soon become a national goal. At least one State, California, no longer permits the dumping of sludges into the ocean. Officials of the State of New Jersey have made the commitment to eventually phase out ocean dumping of sludges. There is enough etiological evidence that the food producing capacity of estuaries and relatively shallow continental shelf areas has been or is being endangered by ocean dumping of sludges that officials of yet other States would also phase out ocean dumping. What's missing is the sure knowledge that a more environmentally satisfactory and reasonably economic disposal alternative exists.

Incineration is the alternative sludge disposal method most often proposed. Yet, incineration presents many disadvantages such as (1) high cost, (2) air pollution, (3) the input of large amounts of energy and (4) disposal of the remaining ash (since sludge contains about 30 percent inorganic materials).

Another deterrent is the lack of documentation on the cost for sludge incineration. Some of the cost estimates presented in the existing literature are not acceptable because the incinerators being considered were not equipped to meet present day air pollution emission standards. Furthermore, incineration costs must include those for dewatering as a preparatory step. The water contents of raw sludges range from 85 to 99.9 percent.

Sludge dewatering, in all likelihood, would be accomplished by some mechanical means such as vacuum filtration, filter presses or some kind of centrifuge method. Vacuum filtration appears to be the most popular type of equipment. However, reducing the moisture content to even 75 or 80 percent by vacuum filtration means large amounts of chemicals must be added. Normally about 300 pounds of lime and ferric chloride are required to condition a ton of raw sludge.

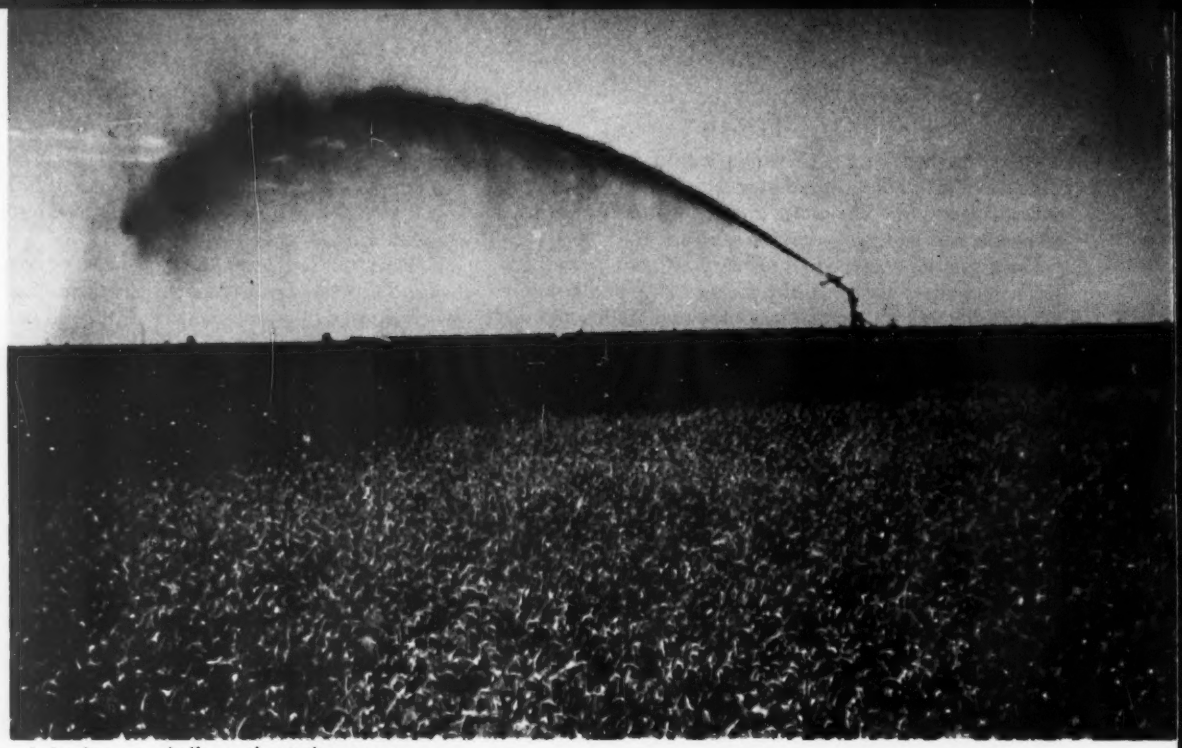
Thus, not only does the initial cost of chemicals add to disposal costs but the added chemicals themselves must be disposed of as constituents of the ash produced by the incinerator. Operating and maintenance costs are bound to be high for properly operated incinerators. A cost of $65 to $70 per dry ton of solids seems to be a fairly conservative estimate for this method of disposal. Even considering long transport distances, *it appears sludge utilization on farmland might cost about one-half the cost for disposal by incineration, if the incinerators are equipped and operated in a manner to meet new emission standards.*

As for air pollution, there are a number of possible hazards associated with sludge incineration. First, some of the heavy metals—most notably mercury, lead and cadmium—are volatilized to some degree under the high temperature conditions needed to completely oxidize the organic materials. Thus, many of the volatilized substances in the air would become a diffused (nonpoint) source of water and land pollution. In a similar manner, many types of chlorinated hydrocarbons may be vaporized, rather than decomposed, and eventually return to the earth's surface in an uncontrolled fashion.

Sooner or later about one-third of the original mass of sludge will return to earth as incinerator ash. Very little is known about the physical and chemical characteristics of this ash. It may pose a considerably greater threat toward pollution of water supplies when disposed of as volatized matter than if left a part of the chemical compounds in the original organic materials. Many of the ash constituents are less likely to move as water solutions while still physically and chemically bound to some of the biodegradable resistant portions of the organic materials in the sludge.

Where large volumes of waste activated sludges are produced, several attempts have been made to dry and sell sludge as a fertilizer. But the demand for such low grade fertilizer is exceedingly limited. Sludge fertilizer contains 3 to 5 percent total nitrogen, an equivalent amount of phosphorus and only about 1 percent potassium. Thus, the handling of the volume of dry material that a farmer would need in order to apply sufficient nitrogen for the production of nonleguminous crops is not as convenient as applying higher grade inorganic fertilizers sold commercially.

Dried sludges have been used mainly in the production of specialty crops where a slow release of mineral nitrogen was desirable and where it was needed to induce the development of a more favorable physical soil condition for growing plants. Besides, the production of sludge fertilizer as a means of disposal has always been a very expensive proposition. To install and operate equipment to reduce drying plant stack emissions to acceptable levels will substantially increase the cost of producing sludge

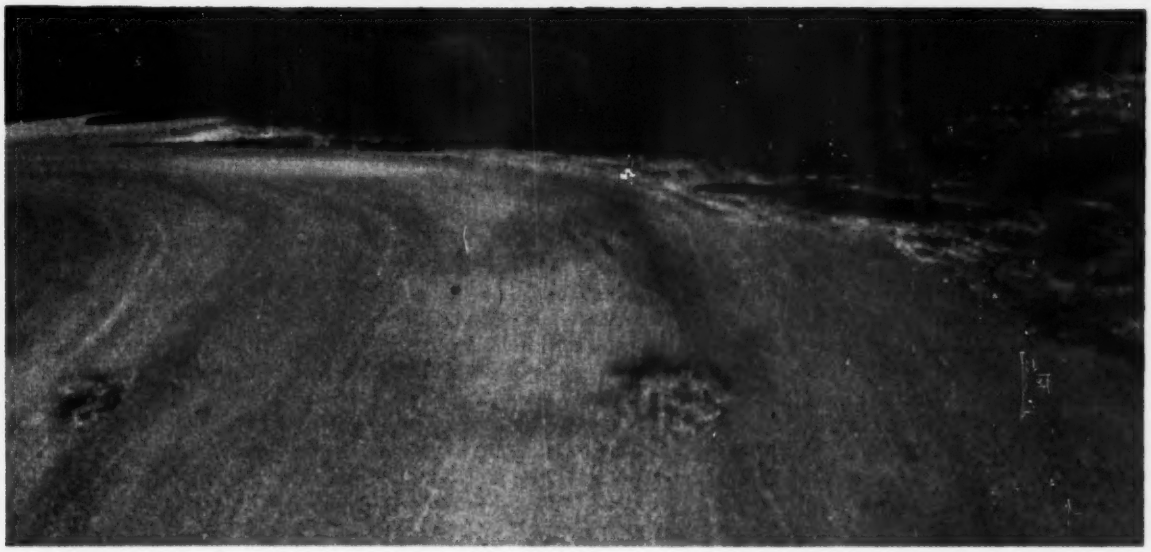


A cable-drawn irrigation gun, similar to the stationary one shown closeup, below, sprays a 330-foot-wide arc of digested sludge across an alfalfa field.

An attachment on this tractor-drawn plow enables a farmer to turn under the digested sludge when his primary need is to conserve nitrogen for future crop production. A different attachment can be used if a direct soil injection method is preferred.

A dump truck deposits another load of frozen digested sludge from nearby Winnipeg, Canada, on a level farm field cleared of snow. A grader then spreads it in this frozen state.

A system of surface inlet terraces is used to control erosion on slopes up to 8 or 9 percent before applying digested sludges. Ringlets of sediment deposits visually locate the inlets in the accompanying photo.



fertilizer, a material with very limited potential for marketing.

In the past many treatment plant operators used anaerobic processes where bacteria not requiring free oxygen digest the raw sewage prior to disposal into sludge drying beds. Sand drying beds were then used to reduce the moisture content of either partially anaerobically-stabilized sludges produced by ambient temperature Imhoff tanks or sludges well stabilized in heated anaerobic digesters. However, the increasingly greater volumes of solids requiring larger drying beds, especially in areas where open space for expansion was scarce and expensive, and the rising cost of labor favored a switch to mechanical means of dewatering. All of the factors that caused the abandonment of drying beds for dewatering sludge also would apply to the cost factors involved in windrow composting of sludge as another method of stabilizing and dewatering prior to disposal.

The usual pattern of handling dewatered sludges has been to haul them out to land fills for burial. In many large metropolitan areas—as land became scarcer, haul distances to landfills became greater, and routes became jammed with traffic—it was found to be more economical to reduce the mass of solids by microbial digestion and then pump the liquid suspensions into lagoons. The use of heated anaerobic digesters was found to be the most economical and reliable method of getting a 45 to 50 percent reduction in the primary and waste activated sludge mass and producing a material that could be stored in open lagoons with few problems. However, land is not only scarce and costly in many rapidly expanding metropolitan areas, but there is also an intolerance by the community toward the relegation of land to such a single use for indefinite periods.

From the great number of methods used for sludge disposal it would appear that at some time and place nearly every possibility has been explored. However, in nearly all cases there was too much preoccupation with measurable dollar costs of disposal, disregarding the costs of wasted resources and environmental abuses. Because the main emphasis has been on disposal by the most economical method, even schemes that encompassed minor aspects of recycling often ended in failure. Environmental insults were simply transferred from one place to another because it was not generally recognized by engineers that, like water, soils also have limited assimilation capacities for waste. The most elementary soil conservation and management practices were usually ignored wherever land disposal systems have been used.

Heated anaerobic digesters can be used to overcome objectionable characteristics of primary and waste activated sludge. Heated anaerobic digestion of sewage solids is used to accomplish two primary objectives. First, about 50 to 70 percent of the organic fraction of sludge solids are biologically converted to methane and carbon dioxide, reducing the amount of total solids that must be handled by about 40 to 50 percent. After digestion, the organic fraction of the remaining solids is sufficiently stabilized against further biological degradation so the material can be lagooned, dewatered on drying beds, or applied on the surface of soils without causing noxious odors or fly breeding problems.

Quite a lot is known about the microbiology and biochemistry of anaerobic digestion processes and, thus, how digesters ought to be managed to obtain the best results. The processes are generally discussed in terms of two phases: first, liquefaction and hydrolysis; second, fermentation and gasification. A rather heterogeneous group of bacteria is used to convert the proteins, carbohydrates and lipids contained in the waste into fatty acids, carbon dioxide and ammonia nitrogen during the first stage. During the second stage strictly anaerobic bacteria convert the fatty acids produced during the first stage to methane and carbon dioxide. Similar processes occur in stomachs of cattle and other ruminant animals. Thus, much has been learned about these digestion processes by the animal physiologist.

In the last few years a great deal of attention has been given to the old idea of utilizing digested sludges as a source of nutrients. Emphasis has been on their use to grow crops and as a soil amendment to ameliorate physical conditions in severely disturbed lands that adversely affect the establishment and growth of plants. *Certainly, disposal by utilization cannot be carried out without cost to the sanitary district involved.* On the other hand, contrary to strictly land disposal schemes, it is envisioned that these solids will be utilized in such manner that land usage is either not changed or, in the case of land reclamation, the number of alternative land uses is actually increased.

In 1968, members of a well known engineering consultant firm estimated the cost for pumping digested sludge containing 3 to 5 percent solids a distance of about 50 miles and distributing it on land in amounts just sufficient to supply the nitrogen needs of nonleguminous plants. On the dual base of a 6 percent interest rate and amortization of all construction costs over 50 years, including maintenance and operation of the sludge distribution equipment, this firm estimated the cost for sludge disposal by agricultural utilization to be $22.30 per dry ton. Others have estimated the cost of pumping digested sludge at 10 to 15 cents per ton-mile. Since cost depends on the tonnage pumped it has been suggested that a geographically connected population of two million people is an economical starting point for considering pumping distances between 50 and 100 miles.

At the present time, for example, sludge is being transported from the Metropolitan Sanitary District of Chicago wastewater treatment plants to an agricultural utilization site 160 miles downstate by means of a unit train. The unit train contains 30 tank cars, each having a 20,000 gallon capacity. Under another contract, sludge is being barged 180 miles from Chicago to a land reclamation site in Fulton County, Ill. While transportation costs vary with the solids content of the digested sludge they have generally ranged from $30 to $35 per dry ton during these short period (3 years) rail and barge haul contracts. With a continuous or sustained operation, transportation costs by rail and barge could be considerably reduced.

On a sustained operational basis it does not appear unreasonable to consider pipeline transportation distances of up to 200 miles from large municipal waste treatment facilities in contrast to the cost of the alternative methods of sludge disposal previously mentioned.

Generally speaking, the application of three inches of digested sludge liquid containing 3 to 5 percent solids will supply all the nitrogen, phosphorus, and trace elements needed to produce a 200 bushel per acre corn yield. Some additional potassium may be needed on soils containing low supplies of the available forms of that element.

Digested sludge can be applied by irrigation equipment during the growing season. A ridge and furrow system using gated pipe has been used very successfully for several years at Hanover Park, Ill., where corn grown on the ridges has been fertilized by furrow applications. But equipment for spray irrigating crops should have large diameter nozzle openings. In this type of irrigation the digested sludge can be sprayed directly on the leaf canopy of the crops as long as this is not done too often; too frequent coating of the leaves will reduce their light absorption, resulting in a reduction of photosynthesis rates and, thus, lower yields.

Digested sludge exhibits its greatest potential value when used as a soil amendment to ameliorate conditions which adversely affect the growth of plants. The organic matter contained in well digested sludge is very similar to natural soil organic matter. Thus, the organic matter content of soils can be increased very rapidly as a result of sludge applications. When applied on heavy textured soils having low organic matter contents, the water infiltration and aeration capacities of soils may be much improved in a very short time. Because of its pH (measure of intensity of acidity in the soil) buffering capacity, digested sludge is especially valuable when incorporated as a soil amendment in order to change soil pH which may be unfavorable for plant growth. Since digested sludge has a neutral pH, heavy applications tend to neutralize either extremely acid or extremely alkaline soil conditions.

Where digested sludge is used as a soil amendment for reclaiming severely disturbed lands, like strip-mined spoil banks or eroded soils, care should be taken to reduce further erosion to very low, acceptable levels. Often, this will require some land leveling and shaping and the installation of water management and erosion control structures before sludge is incorporated. In soils or soil materials exceedingly low in organic matter, it is often desirable to apply much larger amounts of sludge and more frequently than would be required on more normal agricultural soils. Because very little water in digested sludge is absorbed by any soil its rate of dewatering depends, for the most part, on evaporation.

Sometimes it may be desirable to place sludge beneath the soil surface. This will quickly achieve the benefits from the heavy loading rates necessary for reclaiming or upgrading the land. Therefore, after the land has been shaped and protected against erosion, the same types of farm equipment used to inject or turn under large applications of animal waste below the soil surface may prove practical.

However, it must be recognized that since the mineral nitrogen content of digested sludge is the foremost limiting factor on the amounts that can be applied at any one time, placing the material under the surface may reduce the effective loading rate. Surface applied sludges lose 30 to 40 percent of their total mineral nitrogen by evaporation of the ammonia component, but if the same material is placed below the surface very little of this ammonium nitrogen will be lost by ammonia volatilization.

In Winnipeg, Canada, digested sludge is being pumped to shallow lagoons where it is decanted and much of the water is returned to the wastewater treatment plant. The remaining concentrated suspension of sludge solids is about 20 inches to 24 inches in depth and solidifies by freezing during the winter. After the sludge is frozen solid it is fragmented by equipment similar to that used to rip up old pavement materials, loaded into open trucks, and hauled to fields where it is dumped and spread over the frozen soil on surfaces that are level. On more sloping soils and in more humid regions, winter applications of sludge in this manner would present a pollution hazard unless precautions are taken to insure that the material does not erode into streams. Thus, on areas protected from excessive erosion, the application of frozen sludge may be an economical and efficient method of overcoming a difficult handling problem.

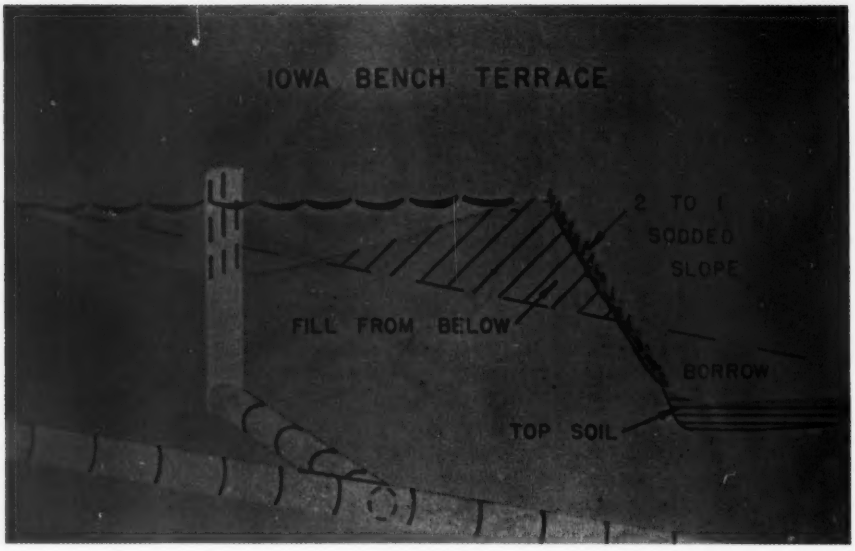
Many people fear that the so called heavy metals in sludges may accumulate in soils to a concentration that would create a toxic condition for crop plants or that they may be taken up in plants in such concentrations that they would adversely affect animals which consume the crops. But these fears have not been substantiated by the results obtained during more than five years of demonstration and research work conducted by members of the Metropolitan Sanitary District of Greater Chicago and the Agronomy Department, University of Illinois. These investigations were supported by grants from both the Federal and State Environmental Protection Agency offices.

Many of the heavy metals are essential for either or both plants and animals in trace amounts. Thus, some low concentration levels of recycled heavy metals will be beneficial to both plants and animals. Most of the trace elements applied as a constituent of digested sludge may accumulate in soils to chemical concentrations several times the levels normally found in productive soils; but the hazard involved cannot be readily predicted, since their biological availability is not proportional to their chemical concentrations.

It is most important to remember that, except for some anion forming chemical elements, the constituents of sludge will be retained in or near the soil surface. These elements will not move laterally from the point of application if soil erosion is controlled to very low levels. *Therefore, since their location in the environment is known, there are soil and crop management practices which can be instituted to eliminate or modify conditions which might be detrimental to plants or animals should such conditions ever develop. We do not have these control options when sludge constituents are disposed of as air polluting stack emissions, dumped in oceans or buried.*

Another important aspect of recycling sludge is the conservation of plant nutrients, especially in view of some forecasts that cheap supplies of inorganic nitrogen and phosphorus fertilizer are dwindling. If these forecasts are proven true *we have yet another reason for being concerned about exploring agricultural reuse of some 480,000 tons of phosphorus each year.* This is the approximate amount of phosphorus in the anticipated 12 million tons of sludge on a dry weight basis that would be produced annually by secondary treatment of all municipal and industrial wastewaters in the U.S.

At the present time, it is most economical to load soils with as much sludge as possible without also polluting water supplies with the nitrate form of nitrogen. But, in view of the energy crisis, it probably



A structure called the Iowa bench terrace system controls erosion on slopes approaching 18 to 20 percent, so digested sludge may be utilized as a fertilizer and soil amendment on moderately steep hillsides.

will not be very far into the future before sludge application will be made on cropland at rates which can optimize crop utilization of the nitrogren and /or phosphorus contained in the sludge.

It has been said that it takes the energy liberated by burning five tons of coal to make one ton of nitrogen fertilizer. Considering all the energy needed to mine the coal and transport both the coal and fertilizer, we may soon find it to be more economical to use the nitrogen contained in both the sludge and effluents remaining after secondary treatment of wastewater.

There is a large expenditure of energy involved in converting agricultural nutrients into a form that may be safely released into the atmosphere. There is a different type of expense involved in wasting these nutrients as we now do through normal waste disposal methods. No matter which method of processing is selected, there is a simultaneous cost in having to buy new supplies of the same materials in the form of fertilizer.

Continuance of such practices will eventually succumb to our increasing awareness that we are paying double for our past technological ignorance. *The environmental role of wastewater has been improperly understood or else we would not have disrupted its natural cycle by throwing its sludge components into streams, oceans, lagoons or landfills, or converting them into airborne matter—a delayed form of pollution.*

The average metropolitan sanitary district adopting sludge recycling to lands requiring extensive reshaping won't necessarily cut its monetary cost for treatment, but will provide environmental relief for the district—and improve productiveness on agricultural hinterlands receiving the sludge. And the deferred payment inherent in rebuilding nearby food producing soils will eventually provide a substantial return on this kind of investment compared with current waste treatment programs. Why continue to waste our waste resources when they can be forever productive? This is one of the *now* questions that should be answered without further delay. We can't afford to wait.■

CONSENSUS the First Step

"The very power to take action against . . . problems is divided among 257 different city and village governments, all of the region's counties and townships, and the alphabet soup of Federal and State agencies involved in the management of water resources."

by Matthew L. Rockwell
Executive Director
Northeastern Illinois Planning Commission

Nature decrees that flood plains flood with regularity, yet construction growth often continues on land that invites disaster. The problem has become particularly acute in heavily populated Northeastern Illinois. Until now there has been limited success in overcoming the developer's penchant for flood plain misuse, *despite an almost overwhelming collection of data and information which show the region's flood plain risks.* Then last summer, events began to bring about a change.

During the summer months it was unusually wet in Chicago and for the six surrounding counties that constitute the territory of the Northeastern Illinois Planning Commission (NIPC). Most streams overflowed. Salt Creek, for example, topped its highest recorded flood crest by five feet in some places, while cresting three feet higher in others. Beyond the reach of flood waters, storm sewers became surcharged, filling street underpasses and backing up into uncounted basement drains. All six counties were proclaimed Federal disaster areas, making their flood victims eligible for low-interest loans to rebuild damaged properties. Later, an untimely winter snow melt caused another smaller flood. Spring—traditional flood time—has been filled with dreaded anticipation.

The events of the last few months have focused public concern on the region's flood problems as never before. Television and newspaper accounts brought the plight and emotions of flood victims to many citizens not directly affected. Among the elected officials who noticed a popular issue developing were two members of the Illinois General Assembly. State Representative Eugene Schlickman told Chicago businessmen that no problem destroys the credibility of government more than floods. State Senator Jack Knuepfer reported that more than half those responding to his poll of constituents favor a State law controlling flood plain construction.

Thus, the opportunity to enlist enough support to solve flood problems may have come. The problems, however, are too complex for any simple solution. To start with, the very power to take action against these problems is divided among 257 different city and village governments, all of the region's counties and townships,

Development of flood plains continues despite irrefutable evidence of flood risks.

This sign reflects the tendency to overlook risks, and each development that makes a profit encourages other developments.

and the alphabet soup of Federal and State agencies involved in the management of water resources. These separate jurisdictions have not been well coordinated on any complex problem. Among these units of government, the most effective at preventing flood problems has been the Metropolitan Sanitary District of Greater Chicago (MSD), but MSD is legally limited: geographically to Cook County; functionally to handling only problems related to water pollution. Streams, of course, do not respect village limits or county lines. Thus, water management and land use decisions are interdependent, in ways which involve the private economy, the courts, and plans for parks and highways.

One agency—NIPC—has specific responsibility for anticipating interrelationships on the regional scale. NIPC, however, is limited by law to a purely advisory role, and limited in finances to voluntary contributions and appropriations.

Land use has long been regarded as the key to water management by both NIPC and its predecessor, the private Chicago Regional Planning Association. Land use control is the cheapest, earliest means of preventing flood problems from developing. Other agencies, likewise, tend to stress their own specialities; whether major public works, village growth, emergency help to victims, or research. NIPC gathered all these resources together in a seven week program that led to a Storm Water Conference on March 10. Invited were 4,000 public officials who share the decision-making responsibility in the region. The work of organizing this program has been a broadening experience. We at NIPC have learned to regard land use planning less as *the answer* and more as one of many necessary ingredients.

The Storm Water Conference

Public participation is the latest emphasis in planning. The idea has grown out of analysis of past failures, since merely advisory planning can be an exercise in futility. As a distinct technical specialty, practiced in its own separate offices, planning becomes isolated from the full process of problem solving. Technical solutions are ignored as coming from an ivory tower; or if insisted upon, their sources are resented as usurping leadership. Elected leaders and businessmen, meanwhile, continue to cope as best they can without the technical backup they could otherwise have.

The planner should not shelter himself from the idea marketplaces of politics and business, but should invite decision-makers into full participation in the planning process. The Storm Water Conference attempted to increase the efficiency of the idea marketplaces by bringing the whole spectrum of flood ideas to a meeting of decision-makers. The planners stood on the sidelines as aides, not manipulators.

Preparation for the conference began in January at meetings with flood victims in their own communities to list all the problems they face. A telephone poll of storm drainage experts began at the same time. In February, two questionnaires were mailed to elected public officials. The second questionnaire reported the results of the first, and asked political leaders to comment upon each others' ideas.

On March 10 the morning of the conference was devoted to reaching agreements among all the elected officials present through small group discussions. Each group ranked by vote the list of solution ingredients generated by the questionnaires. The small group findings were then combined by a vote of the entire conference. This final ranked list was presented to the State

Public awareness of the plight of flood plain residents during the last few months is focusing attention on uses of yet undeveloped flood-prone areas.

Planned retention of flood water in surface reservoirs such as this is part of the plan for newer suburbs.

and Federal leaders attending, who responded to the local consensus that afternoon.

This type of public participation project is an experiment. We realize that the division of responsibility for solving flood problems may have to be worked out in more traditional ways over a longer time. *NIPC was greatly encouraged to try it, however, by political leaders who need consensus as the first step in the decision-making process.*

Help in Flood Emergencies

In preparing for the conference, NIPC learned that flood victims want to be warned when the creek is rising and is expected to go over its banks. Flood victims want help to evacuate their handicapped, neighbors, and to remove their possessions to some safe place. They want expert advice on how to limit damage to their homes. They want portable toilets. They want police protection from gapers, looters, and vandals. Five months after the last flood water receded, victims were still carrying water to their homes and taking their clothes to the laundromat. Their private wells had not been recertified as pollution free. Their septic system drainfields were too saturated to absorb the water from a washing machine. Signs advertising homes for sale dotted the lawns, but the piles of sandbags near every house would warn any prospective buyer that some special problem exists. Many houses are boarded up. Occupants have found safer places to live, but are afraid to repair their property until the promised dike is built. Double mortgage payments add to the financial problems of ruined furniture, appliances, and household contents.

The social services which could help are provided spottily, by a fragmented non-system of public volunteer agencies, each narrowly specialized. No one is responsible for comprehensive elimination of gaps and duplication in meeting the total need.

Disaster loan checks from the Small Business Administration (SBA) were slow in coming, some flood victims said. The SBA regards disaster loans as a temporary expedient, to be replaced as much as possible by flood insurance. This insurance is subsidized by the Federal Government, and is available only in communities which have taken steps to prevent the creation of more disaster neighborhoods. Nine suburbs quickly adopted the necessary flood plain construction regulations and flood disaster plans which qualified their residents for flood insurance in late 1972, though none had applied for eligibility in previous years. Communities declared eligible for flood insurance become ineligible for disaster loans in future floods.

Moving and Storing Water

The basic problem of how to deal with surplus flood waters is controversial, depending on where you live relative to the flood. People who had water in their basements caused by inadequate storm sewers wanted larger pipes. People who lived beside the receiving streams wanted no more unregulated dumping of water. *At NIPC's first meeting of flood victims, two neighborhood groups recognized, for the first time, the conflict between their solutions.*

From this neighborhood scale up to the largest flood control projects, the same conflict exists. Larger storm sewers, stream cleaning, dredging, channel straightening—all can move water faster from where it falls as

High risk development of flood-prone areas such as this is being discouraged through a concerted effort to dry up loan funds.

rain. But never to that mythical place called "Away." Downstream of any such project, overbank flooding increases in some other community. There the demand is to build a dam to hold the water back, increasing floods upstream. Historically, Americans built their largest river engineering projects in the late 1920s and early 1930s. The trend since then has been toward delaying flood water in ever smaller and more numerous reservoirs, ever farther upstream.

The logical end of that line of reasoning is on-site retention, which MSD has required since January 1972. All new developments of more than five acres—subdivisions, apartment complexes, shopping centers, and industrial parks—have to provide retention of the water they receive from what would be calculated as the largest probable rainfall of a century-long period. The water must not flow from the site faster than if only a three-year rain had fallen. Retention sites can be rooftops, parking lots, decorative lagoons, or merely a grassy depression extending across all the back yards in a block. With this approach, storm sewers are deliberately small.

On-site retention applies only to new developments. Redesign of older neighborhoods would probably be too difficult. Instead, storm drainage must be made faster in many older communities. How can this be done, though, without creating the need for more dikes along the streams? Or as one flood victim asked, "Where can the water go when the creek is already higher than the sewer?"

The Underflow Plan

The MSD, forced to answer that question, found a brilliant solution. The problem to be solved is the combined sewer area—consisting of Chicago and several of the nearest and oldest suburbs. Until half a century ago, only one pipe system was usually built to carry both sanitary sewage and the runoff from rains. Thus, today, huge quantities of diluted raw sewage overflow from the old combined sewers into the Chicago River during major storms. Locks must be opened to release the largest floods into Lake Michigan. Federal and State pollution boards are insisting on a better method, but separating sewage from storm water would require digging up the entire street system, at astronomical cost.

The solution is the *Chicago Underflow Plan* adopted by MSD last October, which will store the flood in underground reservoirs. The reservoirs will have the shape of huge tunnels in the rock, hundreds of feet directly below the stream beds. After the flood danger is past, the water will be pumped up into sewage treatment plants and discharged into the river. Much coordination is needed between the MSD, the City of Chicago, and the many Cook County suburbs which will be drained by Underflow. The cost, in the billions of dollars, has become an even larger problem since the freeze on Federal matching grants was announced in January.

Surface Reservoirs

By comparison, the cost of storing flood water is less where vacant land is available for surface storage. The Upper Salt Creek Basin project located in the newer suburbs outside of the combined sewer area will depend on its surface reservoirs and channel dredging. This is a

This resident, who was a flood victim last fall, takes preventive measures against the 1973 flood season.

joint project involving the U.S. Soil Conservation Service, the State Division of Water Resource Management, MSD, the Cook County Forest Preserve District, and the affected suburban municipalities. The largest reservoir will be on public recreational land owned by the Forest Preserve District. Construction costs will be in the tens of millions of dollars for which appropriations are being sought in the current General Assembly. It was a similar flood control project in the 1930s that provided the multi-purpose Skokie Lagoons on the North Branch of the Chicago River.

A decade elapsed from the time the Upper Salt Creek project was first designed and urged until all the necessary participants had signed an agreement. Another decade may pass before the work is complete enough to lower flood crests along the creek. The Division of Water Resource Management plans to build a 10-foot dike to keep Salt Creek out of one subdivision until then. It will cost an estimated $600,000 to protect 180 houses.

No respecter of political boundaries, Salt Creek leaves Cook County in its middle reach. In DuPage County, some of the small sanitary districts and villages have resisted the efforts of NIPC and the Illinois Pollution Control Board to organize a regional system of water pollution responsibility. No large local natural resource agency, such as MSD, exists to lead the middle reach communities toward a comprehensive flood solution and the DuPage County Forest Preserve District is too new to have acquired sites large enough for reservoirs. Also, *development of the flood plain currently is faster here than in any other portion of the region. It is obvious the time required to design, agree upon, and implement solutions must be shortened.*

River basin steering committees have been formed by citizens in several parts of the region. Each of these groups, by comprehensive planning, is trying to foresee its own land needs for future reservoirs. The Corps of Engineers, in a parallel effort, has tried to mobilize public participation, particularly in the Little Calumet River Basin, and in connection with its own comprehensive Chicago-South End Lake Michigan wastewater study.

The Land Use Approach

The land is not a blank sheet, where any dream which can be drawn on paper can be realized with impunity. This is visually obvious wherever mountains or lakes, instead of real estate, occupy the earth's surface. The extremely flat land of northeastern Illinois is somewhat deceptive in this respect. The flood-prone areas are not readily distinguishable from the surrounding land to people who have not seen this locale at its wettest.

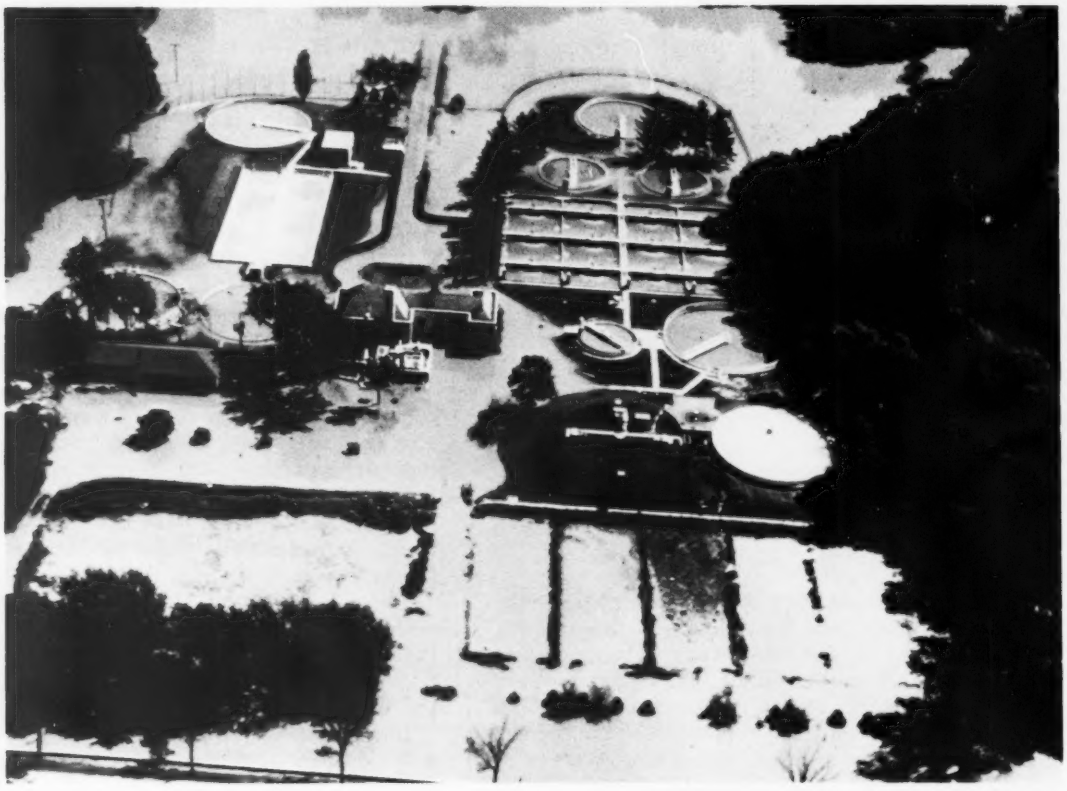
The region is not efficiently drained by nature, which takes a million years of flowing water to create a rolling landscape. Northeastern Illinois was planed flat by continental glaciation ten thousand years ago, and has not yet recovered from this relatively recent geological alteration. A series of parallel moraines serve as makeshift drainage boundaries. Large rivers have not developed. In pioneer days, the smaller streams had no incised channels, but seeped through rushy swales a mile wide and only inches deep. This flow of muddy water was so slow that springtime canoeloads of beaver pelts could be floated across the Epicontinental Divide between the Great Lakes and Mississippi Basins.

Natural flood reservoirs still extend hundreds of feet wide on both sides of the region's streams. If any of these flood plains are filled by man to raise the land surface above flood level, the next flood simply invades some other land.

The floods of this low-lying region are not torrents capable of sweeping buildings downstream, but rather the gentle two-foot rise into the living room that costs 25 percent of the value of a house and 60 percent of its contents, as George R. Phippen estimates.[1] Harder to measure are the heartaches and hardship of living in a camping trailer in one's own backyard for months while cleaning up the mess, and wondering if the renovation loan will be repaid before the next disaster.

[1]Water Spectrum, *A New Course to Ararat*, Summer 1971.

Private development in the flood plain calls for municipal services. And the subsequent public loss, in this case, was accompanied by knocked out sewage treatment for the area.



Flood Forecasting

Since 1961, NIPC and the United States Geological Survey have been mapping the highest recorded floods of the region. The series now includes flood hazard maps of 63 topographical quadrangles. Each of the maps was sent to the respective local governments when published, along with a copy of NIPC's *Model Flood Plain Ordinance*. The model ordinance prohibits any construction which would impede the flow of water at its record high level. It requires both fill to raise any future building in the flood plain out of harm's way and a compensating excavation nearby in order to preserve the flood plain's water storage capacity.

Too few suburbs and counties have adopted this ordinance or enforced its provisions after adoption. Thus, construction of future disaster subdivisions has continued year after year. Part of the problem is that the maps tend to understate the extent of the hazard area. The records on which the maps are based have been kept for only 20 years, too short a time to include the rarest and worst floods. (In any given year, the odds are one percent of having the hundred-year-flood.) Another contribution to the problem is the fact that 36 square miles per year are urbanized in the region. This replacement of trees and cornfields with roofs and pavements speeds water runoff and raises flood crests. Therefore, flood levels forecasted upon the basis of existing urbanization would soon become obsolete.

A more sophisticated approach to flood forecasting is being tested in a pilot project. NIPC hired Hydrocomp International Inc. of Palo Alto, Calif., to design a computerized model of the flood behavior of the North Branch of the Chicago River. Changes in the landscape, such as urbanization and channel dredging, are represented by numbers in the model. The effect of changes on flood height, duration, and extent is easily demonstrated. The model shows that some worsening of floods is inevitable as land is developed. It shows unprecedented catastrophe if the reservoir function of the flood plain is eliminated without artifical provision for equivalent water storage.

Preserving Flood Plains

How can flood plains be preserved? Prohibiting all development on land subject to flooding has been suggested. Courts would have to rule whether this would

Property values drop after flooding and sales are slow. Too often for too long the flood victims who move out are saddled with two mortgages, with two house payments each month.

This flooded area is a golf course on Salt Creek; and although damaged, the loss was light compared to what it would have been if the land were covered with houses.

be an unconstitutional confiscation of property without compensation. If so, the legal alternatives would be to purchase the land for some public use.

Coincidentally, the region does not have enough open space to meet its recreational needs. Sustained suburban growth for decades has not been matched by acquisition of new parks and forest preserves. In fact, among the 10 largest American metropolises, northeastern Illinois actually ranks last in open space per 1,000 population. Thus, on summer weekends, Chicagoans and suburbanites overload the facilities of four States in their search for picnic, golf, and fishing sites. Highways are jammed as in a weekday morning rush hour.

To catch up with these current deficiencies and accommodate projected population growth to 1976, the NIPC *Regional Short Range Open Space Program* calls for acquisition of 90,000 acres of public open space. Of the high priority sites identified in the program, 40,000 acres are in flood plains. The very streams which make this land unsuitable for development enhance its recreational value.

Money is the primary obstacle to effectuating open space land acquisition programs in northeastern Illinois. Since many other demands confront Federal, State, and local budget makers, open land for the weekend or the future is pushed far down on the priority list. On top of this, the flood plain land most threatened by development is priced too high for forest preserve districts, park districts, or the Illinois Department of Conservation to purchase.

Flood land is typically developed last, but when a community reaches 60 to 80 percent urbanization, the temptation is strong. Then *building booms inflate prices to a level which implies the flood plain is habitable, and each development which makes a profit encourages others.*

The Role of the Private Sector

Such speculation in land which must ultimately be unloaded upon the unwary is nothing but a real estate bubble. Americans have been taken in by many bubbles; but eventually everyone wises up and the bubble bursts. Flood plain land in northeastern Illinois must eventually come to the same end. Some signs are visible already.

In November, NIPC mailed information about its flood maps to every bank and savings and loan institution in the region. The response was a deluge of orders, from every part of the region. The largest mortgage lenders (Continental Bank and Talman Federal Savings), with reputations too valuable to stain, are the largest map customers. The reason is simple. Typical mortgage lenders have more applications for each monthly loan committee meeting than they have money to lend and prefer to eliminate the least safe properties by objective criteria. Thus, our flood maps help them meet their business needs as well as serve the larger public interest. *We hope to dry up the private funds available for flood plain development, and bring the price of this flood prone land back to reality.* Open space could then take a second look at such sites as the banks of Salt Creek.

The flood plain of Salt Creek in DuPage County was occupied by only five houses and two commercial buildings in 1954. *Alcott's Blue Book of Land Values* suggests that at that time the entire flood plain could have been purchased for under $1 million. By 1964, however, the same flood plain had 409 houses, three industrial buildings, three commercial buildings, and two schools. Although all were damaged to some extent by the floods of that decade, development of the flood plain continued in subsequent years. As a result the flood damage totals were easily over $1 million on that flood plain in 1972 alone.

Any of the solutions available now will cost much more than acquisition of land would have before development began on the flood plain. Even today, however, like beads on a necklace, Salt Creek is strung with country clubs, private daily fee golf courses, occasional forest preserves and local parks, undeveloped land, quarries, and other uses which are not damaged by floods.

As brought out in the March 10 conference, it would be irresponsible to let suitable uses of the Salt Creek and other flood plains of the region be replaced with more flood plain disasters, to create a never-ending need for more flood control projects. The general accord on this point will surely lead to subsequent steps to correct the region's long standing problems.

The ranking of flood and drainage solutions to these problems by the 550 conference participants places priorities on such steps. These participants—consisting of about half elected officials of Northeastern Illinois and the other half predominantly appointed officials and professionals—ranked the *retention of water where it falls*[2] as the most important solution category.

They ranked as less important these five categories: the halting or further construction on the flood plains; providing more funds for flood control reservoirs, levees, and for the Chicago Underflow tunnel plan; coordinating the many agencies and local governments which share the responsibility; preserving flood plains as natural reservoirs; and improving sewer and channel systems.

Ranked last of seven categories, by a significant margin, was elimination of obstruction to flow in streams.

Participants discussed and voted on many more detailed questions. Their answers are still being analyzed, and NIPC will publish the results.

NIPC is confident that a spark of common cause was struck that will unite the decision-makers of the region into an attack on the prevailing attitude toward overdevelopment of the flood plain. The conference gave direction for such an attack. It brought planners and decision-makers to this consensus: development of the flood plain *must* be controlled for the optimum good of the region, and that the primary effort *must* be directed toward on-site retention of storm water. ■

[2]This concept and retention methods were discussed in *"Storm Water for Fun and Profit," Water Spectrum,* Fall 1970.

In the water resources field, U.S. and Soviet professionals will pool information, discuss each other's ideas and plan research, using experience developed in either country.

US-USSR Expertise Exchange

Until the recent thaw in relations between the United States and the U.S.S.R., our contacts with the water resources activities in the Soviet Union were sporadic and limited to specific interests, study visits or contacts through scientific conferences. In April 1972, during the President's visit to Moscow, a number of agreements between ourselves and the Soviet Union were signed. The ones that received the most public attention were the Strategic Arms Limitation Agreement and the Space Agreement; but others signed at the same time deal with a wide range of cooperative activities concerning such areas as the environment, health, and science and technology.

To implement the agreement on science and technology activities, a joint commission was set up with the President's Science Adviser, Dr. Edward E. David, Jr., as the U.S. Chairman and Academician V. A. Kirillin as his U.S.S.R. counterpart. Mr. Kirillin is Deputy Chairman of the U.S.S.R. Council of Ministers and Chairman of the State Committee for Science and Technology.

In July 1972, Dr. David and Mr. Kirillin met in Moscow to discuss the program in general and to select fields in which cooperative activities might be started. At that meeting they identified six fields for early action. These are agriculture, use of computers in management, chemical catalysis, microbiological production, energy, and water resources. It should be emphasized that this is a starter list only. Other areas may well be taken up under this agreement, but initially it was felt that we both were ready to go in these six. What will be added or even dropped from this list is a matter for future determination.

Water resources was selected by both sides as a field for cooperation, recognizing that both countries have large on-going water resources programs and in the belief that by pooling our knowledge through working cooperatively on selected scientific and technical problems there will be beneficial results for both parties.

To identify specific activities which should be undertaken in the field of water resources, within the framework of the science and technology agreement, a joint U.S./U.S.S.R. working group was set up under the David/Kirillin Joint Commission. On the Soviet side, this joint working group on water resources is chaired by Mr. I.I. Borodavchenko, Deputy Minister for Reclamation and Water Resources. The author is the U.S. chairman.

On September 25, 1972, the working group opened its first meeting in Moscow and in the course of the next few days selected a number of specific activities that it is recommending to the Joint Commission. The Commission plans to meet early in 1973 when it will have placed before it specific recommendations for action in water resources. Soon after that, work can actually start. The kind of work envisioned under this agreement are joint studies or research activities on specific topics of mutual interest. With this science and technology agreement as the instrument, workers in

corresponding fields in both the U.S. and U.S.S.R. would be brought together in a number of ways so that they can pool the background of information they have at their disposal on specific topics, discuss each other's ideas and then plan research activities. These research activities will most likely be interlocking programs pursued separately in the U.S. and U.S.S.R. In many cases the activities in the U.S. will be those in which various Federal water resources agencies are already involved.

Through the cooperative agreement, the U.S. activities can be made more productive by involving the Soviets in an appropriate manner. No doubt they likewise feel there will be benefits in working with us. In some cases the proposed activities are joint studies of scientific problems where the benefits will be for all who are concerned within a specific field, no matter whether they are in the U.S., the U.S.S.R., or anywhere else. In other cases, the U.S. has invested in and developed certain technologies important in water resources activities such as special cements, coatings, concrete treatments, etc. The Soviet Union having a similar need, has also invested in similar endeavors.

Until now these research and development activities have gone along more or less separately, although we are somewhat aware of what they are doing by reading their technical literature. Now, through this science and technology agreement, experts on both sides would be brought together in such a manner that they can plan their activities jointly, using the experience developed in either country.

For instance, if we can obtain from the Soviets the results of experiments that we might otherwise undertake ourselves, we could save the cost of undertaking duplicate work. This, we believe, will occur in many instances. In other cases we have developed methods and procedures in water resources planning which we are in the process of refining. Their use of some of our pro-

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Dr. Butcher, while in the former Office of Science and Technology, Executive Office of the President, served as the U.S. chairman of a joint working group to identify water resources activities that could be undertaken through a U.S./U.S.S.R. science and technology agreement.

Geographic location of the U.S.S.R., when compared with North America's, shows almost two-thirds of her land lies above our 49th parallel border with Canada and a sixth of her total area is north of the Arctic Circle.

The slumbering Siberian taiga is a source of runoff representing a vast untapped water resource.

The city of Bratsk and its hydropower station constitute a single project under the Soviet system of budgeting civil works.

cedures under their circumstances may offer test data which we can use to refine our processes even better. No doubt the same is true from their point of view. They may possibly gain more than we will from working on some topics, but in other topics the reverse will be the case. As the Joint Commission makes its decision on the recommendations of its water resources working group, both sides will want to see that a balanced package of activities is endorsed.

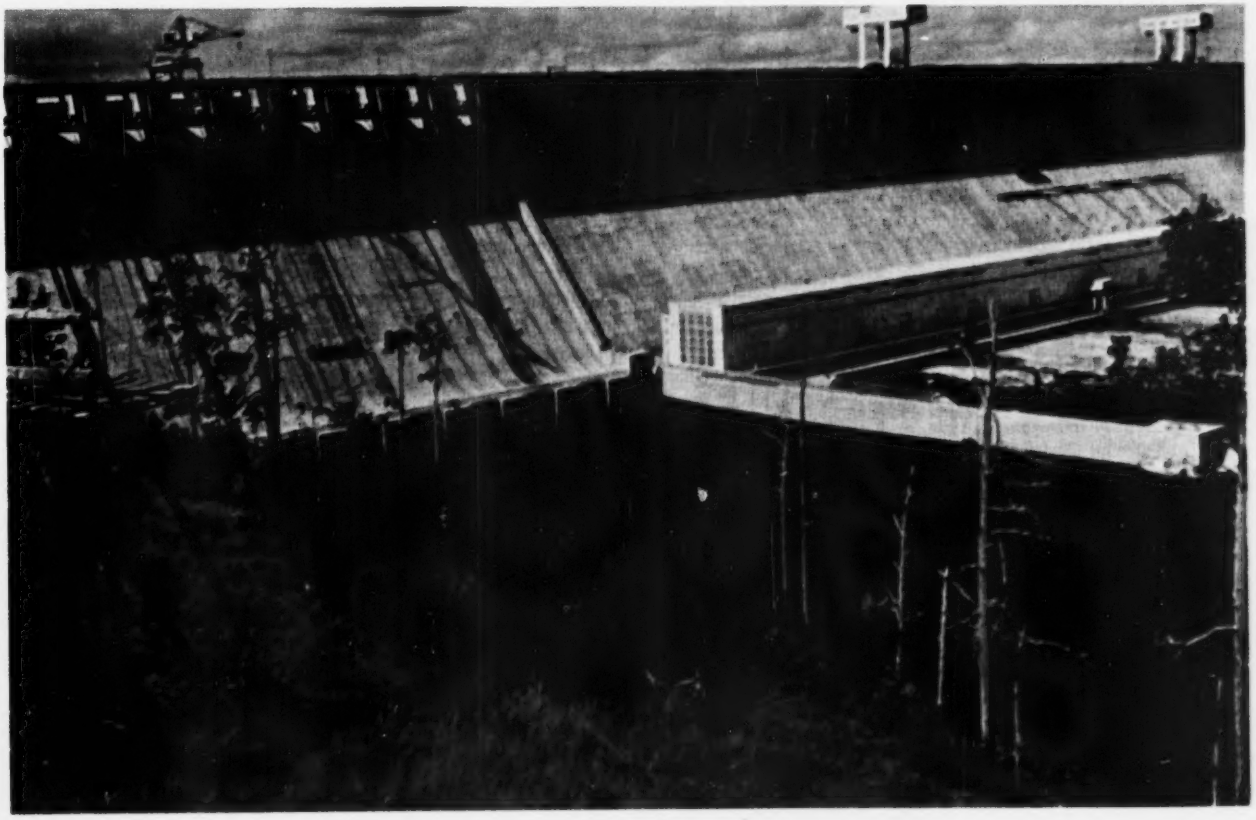
The activities which we are proposing under this agreement are, in reference to water resources, all within Federal agencies, and these agencies were all represented on the U.S. side of the working group that drew up the proposals. We expect the cooperative work will initially involve the U.S. Army Corps of Engineers, the Department of the Interior's Bureau of Reclamation, as well as the Soil Conservation Service and the Agricultural Research Service of the U.S. Department of Agriculture.

On the Soviet side the Ministry of Reclamation and Water Resources will be the principal cooperating organization, although actual cooperative activities will involve a number of the Ministry's outside laboratories and planning organizations. Since this Ministry's principal function in the U.S.S.R. is restricted to development through irrigation and drainage, it does not control all uses of water resources. Under the U.S.S.R. system, the Ministry of Power is responsible for generation of hydropower and so is charged with building the larger dams. In addition, the latter Ministry's projects are more often located in colder climates than is the case with irrigation developments. Thus, we plan to be working with both Ministries, giving us access to a wide spectrum of water problems in the Soviet Union.

Although the specifics of the cooperative activities must await the decision of the Joint Commission, the very existence of proposals for joint study raises a number of important questions, including the extent to which we share comparable water resource problems and hence can mutually reinforce each other's scientific and technological approach to them.

In 1959, under the Cultural Exchange Agreement between the Soviet Union and ourselves, a group under the leadership ot Senator Frank E. Moss of the Senate Committee on Interior and Insular Affairs, including representatives of the Senate Committee on Public Works, traveled to the Soviet Union to visit sites of water and water power resource development. Following their return it was reported:[1] "The Senate observers saw nothing in the Soviet program in the nature of a scientific, engineering or technological breakthrough . . . and that all procedures, technique and know-how appear to be

[1]*Relative Water and Power Resource Development in the U.S.S.R. and the U.S.A.* Senate Document No. 71, 86th Congress, 2nd Session, (Government Printing Office, Washington, D.C. 1960). Page 171.



familiar to American engineers engaged in similar endeavors."

From limited personal observation this is still true by and large. However, it is now 13 years later and it might be better to state that we and they are all part of one water resources fraternity. While they would appear to have no secrets that are unavailable to us, if they will share the results of some of their studies and experiences with us and we share some of ours with them, we will both benefit. It is in this spirit of mutual cooperation between peers that the work under this agreement is being approached.

The relevance of the proposed cooperation is best seen in the context of the water resources problems facing the U.S.S.R. and the steps they are taking to deal with them. First, by way of comparison, it should be remembered that the area of the U.S.S.R. is about two and a half times that of the United States and its population of 240 million is approximately 15 percent more than our 205 million.

The usual measures of water resources development show a number of comparisons. Their irrigated land, for instance, amounts to 26.5 million acres compared with 42 million acres in the United States. In terms of hydropower, the comparison is approximately two for one in favor of the United States. In inland commerce, the amount of goods moved by water on the inland waterways in the United States is almost three times that of the U.S.S.R., and the mileage of inland shipping routes in the U.S. is 60,000 compared with 88,000 miles in the Soviet Union. By these and other measures the U.S. and the U.S.S.R. appear to be dealing with the same order of magnitude in terms of water resources problems and the developments that have taken place in response to them.

One important difference between the U.S. and U.S.S.R. is the geographical situation in which the water flow takes place. Most important, the U.S.S.R. is situated in latitudes more northerly than the United States. If the U.S.S.R. were to be compared geographically to any major country of the world it would correspond more with the latitudes of Canada than the United States. For example, Moscow is as far north as the southern tip of Alaska and the southernmost parts of the Soviet Union would compare in latitude with northern California, Utah, Colorado, etc.

In addition to being more northerly than the U.S., more than half the country (54 percent) drains northward into the Arctic Ocean. Also, this northward draining part of the country is the source for the bulk of that country's runoff, which drains through noncultivated areas consisting of forest, swamp or tundra. This runoff toward the Arctic Ocean, approximately equal to the total of all U.S. rivers, represents a vast, largely untapped water resource which the Soviet Union is concerned with developing. It is in the more southerly parts of the U.S.S.R., where the climate is warmer, that a large part of their water resources development has taken place. This development has been mostly in the form of agricultural irrigation and the associated generation of power. Today 45 percent of these irrigated lands are in the central Asian republics of the U.S.S.R.

Underlying the whole Soviet approach to water resources is the fact they are still heavily involved in the development phase. The more advanced uses of water, such as recreation, are becoming more important in the United States, but have yet to make any great impact in the Soviet Union. It might be noted, however, that a real concern for pollution control exists in the Soviet Union although their actions to deal with this are more in the future than the past.

Soviet Planning Process

In the United States we have developed systems analysis methods to handle some of our planning problems. While we are far from fully developed in this area, we are now making some stumbling steps in what we believe to be the right direction. Talking to planners in the Soviet Union about specific parts of our approach, such as discount rates and various types of accounts (national economic, or regional, for example) does not strike any responsive chord there.

In the Soviet Union development plans are made on the basis of projections of demand for food and fiber; then development projects to meet these needs are planned and authorized. The final approval of a project means that it is eligible for inclusion within the Government-endorsed five-year plan and only when it is chosen for inclusion within this plan can it then go ahead.

The speed and simplicity of this process is in strong

Canals for irrigation projects are lined with reinforced concrete sections poured on site or precast in a nearby town.

contrast to the U.S. approach to such decisions and brings into sharp focus the difference between our two systems of society. Our fundamentally different approach to planning, which deals with principles, standards and objectives in water resource planning (of real importance to U.S. planners), has no counterpart in the Soviet Union planning process. This difference makes cooperative undertaking of studies in those areas impossible at this time.

Unlike a U.S. project, for instance, a Soviet irrigation project includes the building of all houses, roads, schools and other community needs. Therefore, one should recognize the fact that the complete installation of the community associated with that project is paid for under the Soviet system. This makes it difficult to compare total expenditures. All we know is that in the last two years the Soviet Union has budgeted over $6 billion annually for "land reclamation and water resources," which loosely translated, means irrigation and drainage projects. Much easier to comprehend is their present five-year plan, started in 1971, which has a physical goal of providing 2.5 million acres of new irrigated land each year.

Some personal impressions of Soviet projects can perhaps illustrate something of this difference in their philosophy and approach to water development.

Golodnaya Steppe Project

This is one of the largest irrigation projects and, like so many irrigation developments, is in the Asian republics—in this case in the Uzbek Soviet Socialist Republic. The project's existence predates Communist rule, irrigation having been started there in 1913.[2] At that time a somewhat primitive irrigation project was built with 74,000 acres under irrigation. Under Soviet rule, the Northern Golodnaya Canal, about 75 miles long, was constructed to bring under irrigation more land and added drainage ditches. The old project did not have the necessary drainage works and hence signs of salting in the soils appeared as well as an increase in the water table level, which had been an average of 33 feet below the surface in pre-irrigation days.

The project was later increased to 500,000 acres by diverting water from the Syrdarya River. Soon it became clear that the diversion works on this river were insufficient and the Farkhad Dam was built somewhat upstream from the original diversion point. Using the newly available water and additional canals provided enough for the present irrigation of 740,000 acres.

Golodnaya Steppe Project is still being developed and will, when completed, have a total irrigated area of 1,480,000 acres. In this project there are only state farms, which would correspond in operation to our large corporate farms, but in the U.S.S.R. they are all owned by one corporation—the State.

A novel feature of the irrigation activities at the Golodnaya Steppe Project is that instead of excavating earth canals, reinforced concrete flumes are commonly used. These may be either on the surface or slightly elevated depending on hydraulic needs. The precast flume elements are made at factories in the nearby town. Vertical drainage is being used when appropriate to handle drainage problems in this area.

The Soviet Union's great interest in improving irrigation practices includes promoting the use of large water sprinklers. One unit runs along rails straddling a small concrete trench to which water is supplied. This water is pumped up into a lateral distributor which covers a strip of land 330 feet wide at a time. The extent to which sprinkler devices of this or similar design are used is not clear. However, what is clear is that the Soviet Union is making big investments in irrigation, seeing this as a key to increased food and fiber productivity. Hence the investment in sprinklers and other irrigation hardware is being emphasized. The Soviet Union has even negotiated a licensing agreement with a major U.S. manufacturer of farm sprinklers. Recent information is that Soviet reproduction of this sprinkler unit exceeds the manufacturer's own U.S. production volume.

It might also be noted at this point that land levelling to aid irrigation, practiced so widely in the United States, is not used to any great extent in the Soviet Union.

The Soviets are also very much interested in finding out about U.S. technology in advanced practices and automation of irrigation. For example, lack of salinity control through drainage is still a problem the Soviets are facing in many of their irrigated areas. However, this salinity problem would respond to drainage practices such as those being undertaken so extensively in Cali-

[2]A.N. Askochensky; *Irrigation and Water Supply in the U.S.S.R.*, (Mir Publishers, Moscow 1970). Page 164.

Production oriented Soviet construction concentrates on function over cosmetics, apparent in this view of water filling an elevated basin at this pumping station on the Saratov Canal.

fornia's Imperial Valley. The key to this technique is placing underdrains in irrigated land as cheaply as possible. While the Soviets have their own drainlaying machines, they are still very interested in looking at our advances in laying drains and to cooperate in research related to their installation and operation in irrigated agriculture.

Kara Kum Canal

The Soviet Union also has under construction or in the planning phase a number of major water diversion projects. One of these is the Kara Kum Canal in the extreme south of the Soviet Union where the climate is most favorable for irrigated agriculture. This canal, started in 1952, is at present approximately 500 miles long. On completion in 1980 it will be approximately double that length, reaching as far as the Caspian Sea, and will support irrigation in an area of 2.9 million acres. Its source is water from the Amudarya River which rises in Afghanistan. Essentially the canal runs east to west on the U.S.S.R. side of the Afghanistan and Iranian borders.

As constructed so far, the canal is supplying water to augment existing irrigation projects on two major rivers which it intersects and is also taking water to the Ashkhabad region and beyond. While the canal will eventually reach the Caspian Sea, the quantity of water delivered to the Caspian will probably be minimal as the water deliveries along the route will use up the bulk of the flow. However, the existence of the canal will provide a navigation channel from the Caspian through this region.

While this Kara Kum Canal is monumental in size, the technology used is familiar to Western engineers. One interesting feature of the canal's construction was that in working from the upstream end, a pilot trench was excavated into which water was delivered. Dredges floating in this pilot trench were then able to excavate the full size of the canal.

Plan for the Caspian Sea

The Caspian Sea serves as a sink for drainage of a large inland basin and has been dropping in level for a number of years. For 100 years prior to 1930 the level was relatively stable, but in the mid-30s the level began to drop due to the depletion of inflow caused by irrigation losses. It now stands 7.5 feet lower than in 1930.

The recently completed 6,400-mw capacity Krasnoyarsk Hydro Station surpasses the biggest existing hydropower plant in the U.S.

Large imports of water are needed to restore the hydrologic balance there and to support the increased irrigation planned. For instance, the sturgeon catch in the Caspian has fallen disastrously to 20 percent of what it was in the 17th Century.[3] The Caspian also has severe industrial pollution problems, since half of the country's industries discharge into the Volga River which feeds into the Caspian. Also salinity levels are rising and oil pollution compounds the problem.

The amount of water needed to handle the problems there and in the Aral Sea, the Sea of Azov and Lake Balkhash would be sufficient to irrigate over 100 million acres of crops.[4] Even though the return from irrigating crops would be far greater than those from the fisheries that will be protected, the Soviets are now looking at major projects to divert water from their north flowing rivers to the south, enabling them to make up the water deficiencies now showing up in the Caspian and other inland sinks.

Perhaps the one such project closest to implementation would be the transfer of water inland from the north flowing Irtysh and upper Ob Rivers. Information available indicates that the Soviet Union also has under consideration other "river reversal" projects, such as the Kama / Vychegda / Pechora proposal, which would also take water from north flowing rivers and divert them south.

[3]Keith Bush; *"Environmental Problems in the U.S.S.R.," Problems of Communism*, July-August 1972. Pages 21-31.

[4]*"Making Northern Water Available to the South,"* based on an interview with Igor Andreivich Gerardt. Reported in *Pravda*, July 2, 1971.

However, the Ob/Irtysh plan seems favored at this time. Under this plan water from the Ob will be pumped up about 250 feet from a reservoir. It will then flow under gravity through connecting canals into the Aral Sea and hence on to the Caspian Sea through one of its tributaries. The specifics of the project have yet to be decided but the Soviets may have started some of the canal work already.

The plan is that this project will be carried out in three or four stages. In the first stage 20 million acre-feet of water per year will be transferred south. The second stage will double this quantity and the third and fourth stages will continue the increases.

The environmental impact of such a large movement of water has been considered by the Soviets. Since only 10 percent of the total inflow of the Ob River into the Arctic Ocean will be diverted south, they feel that this decrease of north-flowing water will not have any adverse environmental effect. Furthermore, on the positive side, an environmental benefit will be the stabilizing of the Caspian Sea's water level and diluting its salinity with the additional waters. Full restoration of the fisheries will depend on dealing with the pollution problems concurrently.

Hydropower Development

The skill and level of achievement of the Soviet Union in building large dams and power plants is well known. Talking to the engineers who design these major hydraulic structures, one is impressed by the extent to which they are familiar with and are using methods we would use under similar circumstances.

One important difference, however, in the engineering climate of both countries is the relative use of computers in current design and investigation procedures. Soviet

This array of 18 generating units in the machine room at Bratsk indicates Soviet familiarity with methods the U.S. uses for similar requirements.

Women share operation duties at a central control board of a Soviet hydroelectric plant.

engineers use fewer computers and expect a lower performance level from both hardware and software components than we expect from our systems. Thus, they design and build even their largest projects with only minor assists from computer techniques.

In the course of the development of their power resources the Soviets have built some of the largest hydropower plants in the world. When Volgograd Dam and Powerhouse plant was completed 20 years ago, it established a world record of 2.5 million kilowatts of capacity, surpassing the biggest existing U.S. hydropower plant at Grand Coulee Dam in Washington State, until then the world's largest. Since then the Soviets have gone beyond this with construction of the Bratsk hydropower plant, which has a 4.1 million-kilowatt capacity. This again will be surpassed by the Krasnoyarsk hydro plant which was commissioned in 1972. That plant has a capacity of 6 million kilowatts generated by twelve 500,000-kilowatt turbines. This record will stand until such time as the U.S. builds a third power plant at Grand Coulee, making the latter the largest hydropower plant in the world with a 10 million-kilowatt capacity.

General Impressions

In many ways water resources development in the Soviet Union reminds one of this country's immediate past, except that some of the developments are on a scale larger than we had ever contemplated. All the same, the technology used is similar to our own.

In general, the projects seem to be built in a very sturdy manner but with little attention, at least on existing projects, to environmental concerns. From recent discussions it would seem this attitude is rapidly changing. All the same, many of their past projects would be environmentally unacceptable if proposed for construction today in the U.S. and maybe in the U.S.S.R. too.

In particular, I am thinking of the Lake Sevan project in Armenia where a series of dams has been constructed on the Razdan River. While the lake has more than 20 streams entering, the Razdan River is the only one that empties it. The project has lowered the lake level 50 to 65 feet. As a result the old mouth of the Razdan River is now high and dry. This has been partly rationalized by the Soviets as a beneficial means of decreasing the surface area of the lake to control its evaporation, thus making more of its inflow available for irrigation and power. No doubt there are some such benefits, but the Soviet Union is also developing a major project to import water into the Lake Sevan basin to correct this lowering of the lake and, at the same time, make more water and power available in the Razdan Valley area.

A visit to the Sevan/Razdan project by the U.S. members of the working group on cooperation in water resources confirmed the impressions gained elsewhere that Soviet technology, both in finished projects and projects under construction, is comparable with that used in the West a few years ago.

The degree of mechanization, in construction in particular, is not nearly as evident as that seen on a typical U.S. project. However, what is optimum construction practice in our high labor cost economy, where it is economical to use a more mechanized method of operation, would not prevail in the Soviet Union. In the Soviet Union, by contrast, factory produced items and equipment are relatively expensive and labor is not.

In summary, perhaps the most striking feature of their completed works is the lack of refinement in general appearance. Local observers have speculated that this poor appearance is due to an emphasis on production, where quantity rather than quality is the measure by which that production is judged. The heavy emphasis on precast concrete construction accents such things as precast units out of line, and poorly made joints. In many cases it is only the appearance that is affected and, given scarce resources, maybe it is rational for them to economize this way.

Some observers question Soviet motives in participating in cooperative activities, asking if their real desire is not to catch up with our technology and then to surpass us, without actually contributing much on their own part. I believe such a view is based on a false premise. From the Soviet point of view the U.S. is at the forefront of technology. In our economy the market place test, even though it is sometimes applied imperfectly, tends to refine our equipment and methods, improve our productivity and hence our quality of life.

The socialist system, without its market aspect, does not give clear signals about the efficiency of techniques, equipment and the like. We may envy the Soviet's ability to cut through what for us is a maze of administrative procedures and make quick decisions about big items. However, when these decisions are right their methods seem good, but without the checks that our system embodies, the danger of a big wrong decision is also there. For them that danger is minimized if we, as recognized technology leaders in water resources, show them what we have found to be successful.

The fact that their approaches are not exactly the same as ours, on the other hand, will mean that we can benefit from each other's experiences, either from having pursued promising leads in different directions or in facing common problems. Putting together our research activities in a number of fields can be very productive. In this spirit of enlightened mutual self-interest we can build an effective program of cooperation in water resources science and technology.■

new era for MUDLUMPS

Long regarded as natural curiosities of interest only to the academician, Mississippi Delta mudlumps and related phenomena can now be viewed as research topics with important and immediate practical application.

by Sherwood M. Gagliano and Johannes L. Van Beek

In the days of sailing vessels navigation from the Gulf of Mexico into the Mississippi through the delta passes was fraught with difficulties. Ships were often forced to lay at anchor near the entrances to the passes waiting for a favorable river stage, tide or wind in order to cross the shallow river mouth bars in the passes. By the 1850s numerous reports had been made by mariners of yet another cause for delay; this was the rise of mysterious mud islands that formed suddenly in the vicinity of the passes.

Their development was often spectacular, rising as much as 10 or 12 feet within a few hours. Heights of 25 feet above sea level were reported. One particular "mudlump," as these ground protrusions were called, caused great confusion. This one rose from the sea on May 6, 1875, as an instant 30-acre island. In addition to its sudden unannounced appearance, its visual effects included displacement of conspicuous landmarks. Large reed clumps near the channel entrance were thrust laterally 200 feet and pilings in the vicinity took on a 10 degree inclination.

Another of the more noteworthy mudlumps was the one that resurrected a sunken vessel carrying a cargo of heavy stones, leaving it high and dry on the newly formed island.

In more recent years, this geological instability has broken oil and gas pipelines resting on, or slightly below, the sea floor—and even toppled drilling platforms. The best documented cases occurred during the passage of Hurricane Camille in 1969 at Block 70, approximately 12 miles east of the mouth of South Pass. Storm waves generated by Camille between the dates of August 14 and 22 initiated a massive slide on the sea floor. Two platforms standing in 320 and 325 feet of water, respectively, were toppled and displaced. A number of similar accidents have been reported in the lower delta. It thus appears that *a zone of instability and poor foundation conditions extends outward from the mudlump areas to water depths of about 400 feet.*

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The occurrence of mudlumps was described as early as 1528 by Cabeza de Vaca when he discovered the mouth of the Mississippi. But they never attracted scientific attention until the latter half of the 19th Century. The most recent interest concerns suitability of the area as a potential deepwater port site.

Mudlumps are found only in the vicinity of the major delta passes where hundreds have appeared and disappeared through the years. Although many occur as islands, others are identified only as protrusions on the sea floor. Many have lasted for years, as they effectively resist marine abrasion; others have vanished over night.

Their sudden development—along with the occurrence of contorted beds, surface faults and vents through which salt water and gas are discharged—led many early writers to associate mudlumps with volcanic activity. Others evoked early theories of gas pressure; and one scholar attributed them to subterranean water courses (underground rivers and reservoirs originating far inland and discharging into the Gulf at great depths) emptying near the coast and forcing the mudlumps up by their pressure.

Diapiric Punctures

An intensive research program was launched in the 1960s to determine the origin of the mudlumps in the vicinity of South Pass, one of the major outlets of the river. A series of drill holes was made to depths of 700 feet and undisturbed cores of the sediment were taken for

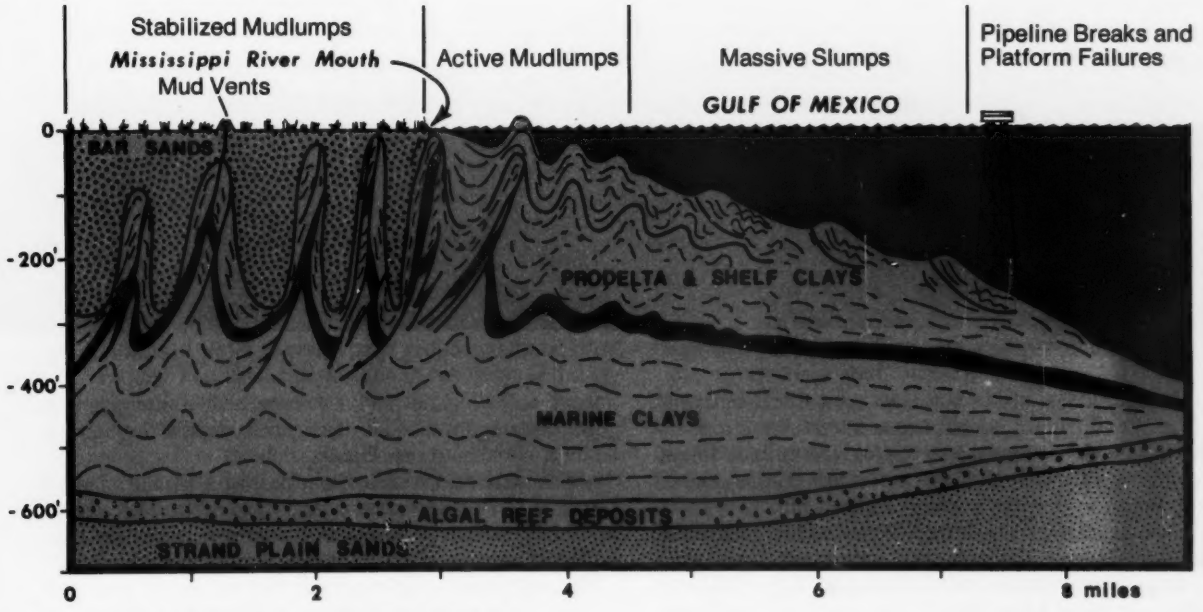
Areas where mudlumps occur and the extent of unstable sea bed conditions in the active delta area of the Mississippi River are indicated by shadings.

This is the appearance of a mudlump shortly after it broke the water surface.

detailed laboratory analysis. A complicated story unraveled as data yielded by the cores were coupled with studies of historic maps, aerial photographs, exposed mudlump structure, bottom topography, and active sedimentary processes occurring in the lower delta. The research showed that deposition of thick, localized masses of heavier bar sediments directly upon lighter plastic clays is the basic cause of the unstable conditions forming the mudlumps. Massive subsurface folding coupled with upward thrusts along fault lines drives diapiric, or mobile, cores of the plastic clays through the more brittle overlying bar sediments. Complete punctures by these mobile cores create the mudlumps.

Project geologists compared the physical, chemical and biological properties of the sediment obtained from the cores with those of samples taken from modern depositional environments in the delta vicinity. They were able to document a series of depositional events that occurred over a period of more than 30,000 years. Once the basic stratigraphic section had been defined and index beds identified it was possible to interpret the complicated structural history of the mudlumps themselves.

Depositional processes associated with delta building are the primary mechanisms of mudlump formation. The bird-foot pattern of the modern delta complex reflects a condition in which sediment deposition dominates over the efforts of marine processes. It results in the forward growth of natural levees extending into the Gulf with little modification. The active delta complex of the



A cross section in the vicinity of South Pass geologically illustrates the manner in which relatively dense river mouth deposits on unstable clays initiate mudlump folding, thrust faulting and massive sea bottom slumps.

The two mudlumps in the foreground appear as islands, the visible lumps of subsurface folds. Four more are incorporated in the end of South Pass spit.

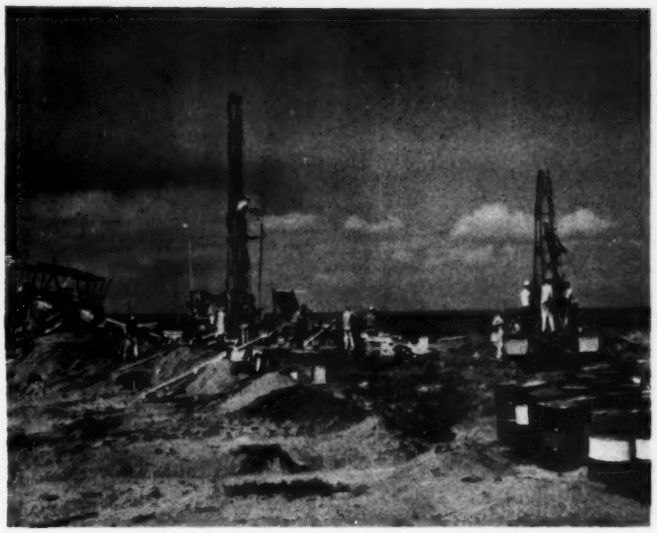
The wave-planed upper surface shows that this mudlump island has experienced a new uplift. Some mudlumps exist for years. Others disappear over night.

This mudlump has existed long enough to have a wave-cut cliff.

Mississippi is the largest and most typically cited example of the bird-foot pattern. Some talons of the foot extend seaward for more than 15 miles. The delta is able to extend itself by building a thick platform of fine grained sediments out into deep waters of the Gulf.

Average channel depth from New Orleans to Head of Passes is 70 feet, although local scours may be 200 feet or more. Distributaries become progressively shallower with successive branching downstream, yet the banks remain well defined. At the channel mouth, however, depth is lost abruptly—causing detrital sediment to spread out in the familiar delta pattern. Here where river mouth bars formerly accumulated under natural conditions, today's jetties and a comprehensive dredging program maintain adequate navigation depths through the South and Southwest Passes.

The pattern of sediment deposition at the channel mouth is controlled to a large extent by decrease in velocity and river energy as the stream leaves the confines of its channel on reaching the basin. Another factor of considerable importance is the mixing of the fresh river water with the salt waters of the Gulf. Relatively light river water flows out as a tongue or plume extending over the denser sea water. The sharp contrast between the turbid, brown, sediment-laden river water and the green Gulf water is quite apparent from the air. At



Research workers take core samples in their study of mudlump subsurface characteristics.

the interface between these two water masses, river-transported colloids carried in suspension flocculate in response to the abrupt salinity change and settle to the sea floor. There is a decrease in both amount and grain size of the sediment deposited seaward of the river mouth as a result of this decreasing velocity and the mixing of river water with sea water.

During low river stage, the freshwater plume becomes very thin, and salt water may gradually progress upstream along the channel bottom. This saltwater wedge commonly reaches New Orleans, 125 miles from the river mouth. Related to the formation of the saltwater wedge is the accumulation of a thick flocculated layer of "sludge" on the channel bottom, particularly in the vicinity of the distributary mouths. This sludge is eventually flushed out of the channels along with the saltwater wedge as flow increases during the rising stage of the river.

Zones of Instability

The sloping underwater platform in front of the distributaries can be divided into several environmental zones on the basis of water depth, type of sediment and bottom topography. The area of deposition of fine clays and silty clays in relatively deep water (120 to 350 feet) is known as the prodelta or delta front. This is the most rapidly changing part of the delta; it includes the distal bar, distributary mouth bar, channel and subaqueous natural levee subenvironments associated with the delta front environment. The entire complex of these associated subenvironments moves in an advancing locus of active deposition that creates the changing delta front.

A combination of size sorting processes and steady advance of the delta seaward results in a highly unstable condition in the delta front and upper prodelta zones. A high proportion of the sediment volume consists of clays deposited by flocculation. Particles of this clay are loosely packed and the deposits are unconsolidated. Although slopes are on the order of only 0.75 to 1.1 percent, they are subject to periodic slumping and gullying caused by density flows or turbidity currents acting on these loose clays.

The advancing delta produces a sequence of deposits characterized by thick and continuous sedimentary beds (approximately 260 feet thick in the vicinity of South Pass). These in turn overlie equally massive older prodelta and shelf clays, so that the base onto which the modern delta is building consists of uniform, poorly consolidated clays more than 500 feet in thickness. Hence, foundation conditions are highly unstable.

As the delta builds seaward, coarser grained and somewhat denser sand and silt sediments deposited in the distributary mouth bars, spits, channel and natural levees accumulate above the thick clay sequence. The effect is unidirectional vertical loading of these concentrations of heavy sands and silts on a very unstable clay foundation. Lateral and vertical flowage and squeezing of the clays occur, and a series of peculiar diapiric fold structures, or mobile clay cones, form immediately seaward of the distributary mouth. *In places along the crests of the folds the surface is distorted and mudlumps are formed.* The synclinal troughs between the folds become filled in with sands and silts as depositional loading continues. Further progradation of the sediment seaward overloads some of the folds and causes them to become asymmetrical (and even overturn), move upward, and develop thrust faults along their axial planes.

By moving in an offshore to onshore direction one may see the different evolutionary phases of these folded belts in the portions exposed as mudlumps. Farthest offshore are bulges where delta front material is being peeled back and exposed along the flanks of the newest folds. Closer inshore these mudlump exposures reveal more mature folds with deeper sediment at the surface. Finally, at the distributary mouths, planed-off mudlump surfaces reveal deepseated, older deposits separated by repeated faulting of the original deposits.

Mudlumps provide a remarkable natural laboratory for the study of these depositional and structural processes with nature serving up these subterranean delta materials for surface examination by man. Normally such deposits would only be obtainable for study in small samples produced by subsurface corings.

Were it not for the import of mudlumps on potential superport sites in the Gulf area, they would still be a subject of academic study merely for the many interesting tectonic features associated with these diapirs. Specifically, these include terracing, mud cones, gas vents, faulting, distorted sediment bedding and brecciation. Terracing develops as a result of periodic pulses in extrusion of the sediment layers; it's directly related to the river stage at the time of formation and may continue for a period of many years. As might be expected, mudlumps grow during floods (particularly major floods) and are usually dormant during low river stages.

Mud cones and gas vents are particularly associated with the faults commonly found. Faulting and distortion abound in mudlumps due to the great forces active during their emplacement. The excellent brecciation and

This mud cone in a fresh water marsh is evidence that a mudlump is underlying the fresh water.

slickensides identify the tilted fault scarps.

A series of well defined fault planes demonstrates where material formerly lying over 300 feet deep has been thrust upward to the surface. These large thrust faults can be identified by correlating cored sections with mudlump surface exposures through use of marker horizons common to both. For example, horizons defining red kaolinitic clay zones, algal reef and shell deposits serve as typical index keys to the amount and direction of sediment displacement.

Mudlumps are a veritable Disney World to the student of rock mechanics and tectonics. Over a period of years the progressive development of folds, fracture patterns and faults can be recorded. Slickensides, brecciation and other features once thought to be associated only with competent rock can be observed in the soft wet clay—previously considered incompetent or too weak to transmit these activities.

Still another illustration of the dynamic nature of these structural movements is provided by the history of drilling casings set in the core of one of the South Pass mudlumps in December 1960. Three strings of below sea level casing were set: 10-inch diameter surface casing to a depth of minus 70 feet, 7¾-inch middle casing to a depth of minus 350 feet, and 5-inch inner casing to a depth of minus 485 feet. During the subsequent 12 year period the outer casing, caught in the upper limb of an active mudlump fold, has gradually tilted and extruded. By 1965 it already stood at an angle of 20 degrees and was pushed up 12 feet. The outer pipe is now tilted at an angle of approximately 60 degrees and has been extruded more than 30 feet.

Superport Search

Recently new attention has been directed to mudlumps and related sea bed distortions in the active delta due to the search for a Gulf Coast location for a proposed superport to accommodate deep draft oil tankers. This search quickly focused on the Mississippi River Delta, where water depths of 100 feet lie within a few miles of the river passes, suggesting an ideal location. However, early evaluations did not consider the constraint posed by poor foundation conditions. Although the entire area has not been ruled out as a potential deep water port site, a more suitable place now is being considered. This site is about 30 miles west of the active delta where the sea bed is more stable.

Formation of mudlumps is only one type of instability. A second and related type involves massive submarine slumping of loose sediments along the upper slope of the delta platform. Sea floor slides, occurring in the poorly consolidated delta front and prodelta clays, are believed to be triggered by wave-generated differential vertical pressures acting on the bottom during storms. Viewed on a broader scale, however, the slides are clearly related to

Continuous discharge of highly fluid mud with the release of gas from a vent causes mud cones.

The uplifted block at right is a raised wave-cut bench.

Below—The irregular surface characteristics of this mudlump is caused by faulting, accentuated by surface runoff.

the mudlump folds and are part of the zone of instability in the active delta.

Mudlumps, delta front slumps and related features constitute a zone of highly unstable conditions forming a broad 60-mile arc around the seaward periphery of the modern delta. The combination of heavy sediment loading atop the plastic clay foundation and an almost simultaneous, or penecontemporaneous, upward intrusion of diapiric clays has created undersea folds with amplitudes of 500 feet and extreme displacements due to the complex nature of the faulting. Massive sea floor slides seaward of these folds affect the bottom to depths of at least 400 feet.

Once thought to be unique to the Mississippi Delta, similar features have now been reported from other parts of the world. For example, mud cones and gas vents at the outlets of the Irrawaddy River in Burma and diapiric folds revealed by accoustical sub-bottom profiling in the Magdalena Delta of Columbia are believed to be similar geological activities.

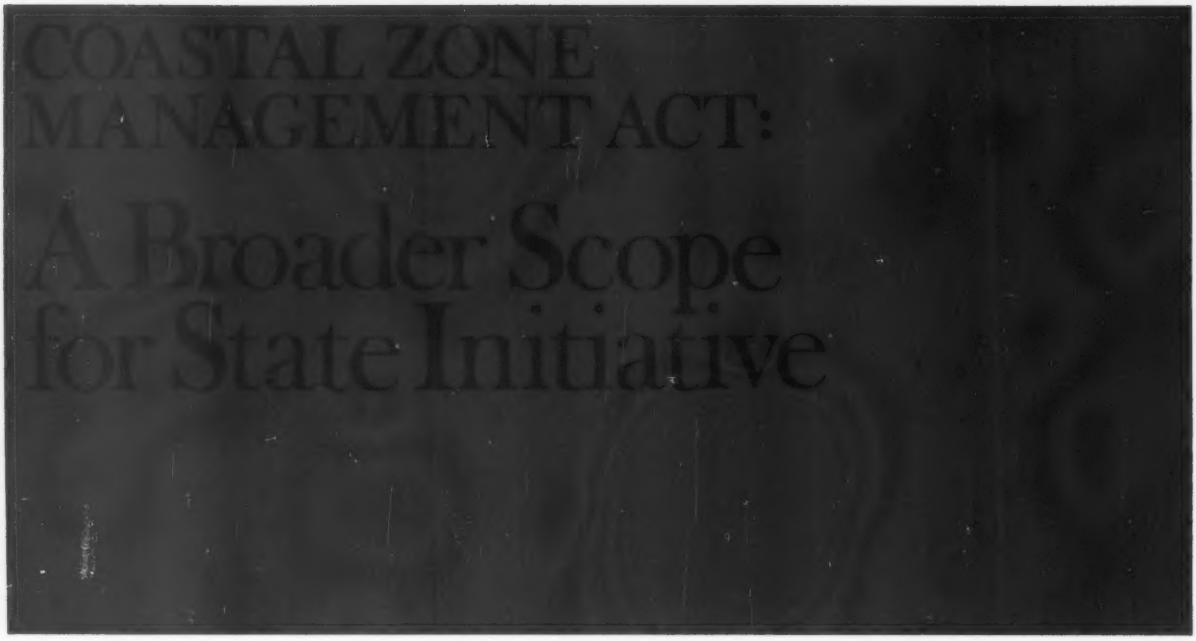
Nature's Hidden Resources

As the mechanics of mudlump formation are also similar to the kinds of diapiric folding which produce salt domes and shale domes—and these are the habitats of oil, gas, sulphur and salt—understanding of these processes has a direct economic application for the delta region.

Geologists have found that some of the major fault zones in the petroleum rich Gulf Coast Geosynclinal Basin may have been initiated by similar sediment loading processes in ancient Tertiary era deltas. Once the zones of instability and weakness were established they persisted as sediment continued to accumulate through time and consequently formed the roots of some of the large growth faults in the basin. Thus, the proper interpretation of such structures are critical, of course, in the search for subsurface mineral deposits.

Long regarded as natural curiosities of interest only to the academician, Mississippi Delta mudlumps and related phenomena can now be viewed as research topics with important and immediate practical application. With the rapid economic growth and development of the Louisiana coastal zone and an increasing interest in dynamic management of the tremendous discharge of water and sediment of the Mississippi River, the importance of understanding these complex natural processes will undoubtedly increase.■

COASTAL ZONE MANAGEMENT ACT: A Broader Scope for State Initiative



by Robert W. Knecht
Acting Director
Office of Coastal Zone Management
National Oceanic and Atmospheric Administration
Department of Commerce

Hon. Peter G. Peterson
U.S. Secretary of Commerce
Washington, D.C.

Dear Sir:

We are owners of a shore property which it has taken us twenty years to obtain. We felt finally that we would be able to get away from the pollution hanging over our city into some clear air for our children and ourselves, but we are finding more and more tar on the beaches. There must be some way we can preserve the natural resources in our land. Before long there will be no place to go. Please do something to stop this.

Very truly yours,

Letters like this one, received by the Office of Coastal Zone Management, have been crossing the desks of State and Federal legislators since the early 1960s. With 100 million of our people within easy traveling distance of the coast and spending increasing amounts of leisure time there, the needs for clean air, clean water, clean beaches, and good fishing are rapidly increasing. At the same time, our growing population requires ever larger port facilities and greater and greater amounts of mineral and energy yielding resources. In the past, decisions concerning the management of our coastal resources were made on an ad hoc case by case basis. We no longer can afford this kind of a fragmented approach. Clearly, the growing importance of the unique and limited resources of our coastal zone, coupled with increasing conflicts over its use, demands a more rational and effective means of development.

Late last year, a national coastal zone management program was enacted by the Congress and signed into law by the President. This article is intended to acquaint the reader with the purposes and provisions of the new Federal program as well as provide him with a brief description of some of the more important management efforts undertaken by State governments in advance of the Federal legislation.

State Action: Conflicting pressures like those referred to above forced some States to act on certain coastal zone problems as early as the mid and late 1950s. In many cases, especially along the eastern seaboard, initial State action was focused on wetlands protection. Legislation of this type came into play often after conservationists and fishermen called public attention to the large quantities of biologically productive salt marshes and wetlands that were being irretrievably lost by dredging and filling for development purposes. The nature of State action has varied, reflecting both the geography and the particular demands placed upon the State's coastline. Typically, however, it has been oriented toward solution of specific problems, usually after crisis is at hand, rather than being comprehensive in scope.

Perhaps the most common approach has been an evolutionary or incremental one, starting with the decision to protect certain natural areas such as dunes, barrier beaches or wetlands. This approach characteristically begins with a systematic inventory of coastal

Land use to prevent coastal zone abuses is one of the problem areas which will receive attention under the new act.

resources, includes an assessment of conflicting demands, and then establishes a program of protection. A management plan and the administrative vehicle for operating it often develop over time. Sometimes what begins as a single focus effort expands to include additional elements and tends toward a more comprehensive program.

The State of Florida provides an example of this approach. In July 1970, the Florida Coastal Coordinating Council was set up to develop a comprehensive plan for management of the coastal zone. In late December 1972, the Council published the first stage of their work, the *Florida Coastal Zone Management Atlas.* The Atlas consists of a systematic mapping of resources followed by the designation of coastal regions, generally as preservation, conservation or development areas. These broad categories are, in turn, divided into sub-categories such as aquatic preserves, hurricane flood zones, and recreation areas. Based on this inventory and assessment, the Council will now proceed to develop the required management plan. A number of other States with plans in various stages of completion are using a similar approach. Among these are: Connecticut, Hawaii, Louisiana, Maine, Maryland, Massachusetts, New York and North Carolina.

Several States have opted to control coastal development for specified time periods or by selective moratoriums, while their long-term planning effort is proceeding. In the State of Oregon, a 1971 act established the Oregon Coastal Conservation and Development Commission to prepare a management plan as a standard against which proposed uses could be evaluated. Until this plan is drafted and implemented, a coastal construction moratorium was established by executive order. Delaware decided on a more selective course by banning construction of heavy industry and most port facilities along its coast. California, whose voters passed Proposition 20 in 1972 calling for a State and six regional commissions to prepare a comprehensive coastal management plan, had given its San Francisco Bay Conservation and Development Commission authority for the comprehensive management of San Francisco Bay as far back as 1965.

Three Great Lakes States—Wisconsin, Michigan, and Minnesota—have established the planning and management process at the local rather than the State level. County governments have been directed to zone their coastal areas under minimal supervision by the State. For example, the Michigan Shorelands Protection and Management Act of 1970 requires an inventory of shoreland use and development characteristics to be followed by preventive zoning for erosion and environmental area protection. If the county units fail to act, the Michigan Water Resources Commission is empowered to carry out the zoning function from the State level. Both the preliminary inventory and a comprehensive plan for management of the coastal area were completed in 1972, and submitted to the public for review. Zoning of many areas was initiated by local units early this year.

At least two States, Rhode Island and Washington, have attempted to meet their coastal problems through

Although the new act is designed to encourage States to develop effective coastal zone management programs, many matters such as the health of estuaries are of keen national interest.

direct and immediate administrative action; that is by establishing comprehensive State management programs. Washington's Shoreline Management Act and Rhode Island's Coastal Management Council Act were passed in 1971 to provide mechanisms for managing the critical developmental problems of their respective coastal areas. The Coastal Management Council created by Rhode Island's legislation was given substantial scope in the administration of a strict permit system to be based on a resource management plan. The Washington legislation also established a permit system; however, it is to be administered by local governments, with the State reserving the right to request review of these decisions before an independent hearing board. The local governments are required to develop "master programs" for regulating shoreline uses consistent with guidelines published by the State's Department of Ecology in June of 1972.

Many of the current States' efforts do not fall into these broad categories. Maine, which has passed a series

of zoning and wetlands management laws since 1967, is working on a plan due for completion in December 1973. This plan will include a land classification system with development standards applied to specific areas, based largely upon procedures developed and tested in the Penobscot Bay area.

In Texas, the State's Division of Planning and Coordination working with the University of Texas, with the support of the National Science Foundation's Research Applied to National Needs (RANN) program, has undertaken a project to quantify the environmental and socio-economic impacts of management policies. And, in North Carolina where the Department of Conservation and Development completed a comprehensive study of the State's estuarine areas in January, a State-Federal committee appointed by the State legislature is working closely with a marine science council in development of a comprehensive coastal plan.

The preceding material, while by no means a complete description of State coastal zone management efforts, does serve to illustrate the diversity of the approaches employed as States attempt to resolve the growing conflicts in their coastal zones.

Federal Action: More effective management of our Nation's coastal zone is not wholly a matter of State concern and attention. The health of our commercial fishing, the effectiveness of our port systems, the provision of adequate recreational opportunities, to say nothing of water pollution control, are matters of keen national interest. Several major national studies were undertaken in the mid-1960s. The results of two such studies, the *National Estuary Study* and the *National Estuarine Pollution Study,* were released by the Interior Department in 1969 and 1970. Both stressed the importance and value of coastal natural resources and the consequences of disturbing their delicately balanced ecosystems. Recognizing the need for action, other reports made recommendations for the application of better management techniques to the coastal zone. An interagency committee of the National Council on Marine Resources and Engineering Development published in 1969 its *Plan for Multiple Uses of the Coastal Zone* which set the following goals:

- establishment of a planning and decision-making process which would rely on the expertise and knowledge of the States;
- development of a structure for consideration of multi-State administrative issues;
- provision of a mechanism of Federal incentives and support; and
- development of a system by which necessary physical, biological, social, and economic data on the coastal zone could be collected and disseminated.

Carrying the greatest weight, however, was the 1969 report of the Commission on Marine Science, Engineering and Resources. The so-called Stratton Commission, charged with developing a long-term national program for marine affairs, recommended a program of Federal grants to help States develop and carry out coastal zone management programs. Congressional hearings and debate on various coastal zone bills took place from 1969 until 1972, when the Coastal Zone Management Act of 1972 (PL 92-583) was passed and signed into law by the President.

The Legislation: The intent of the legislation is "to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone" by encouraging States to develop effective management programs for their coastal areas. The "coastal zone" is defined as "the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder) strongly influenced by each other and in proximity to the shorelines of the several coastal States." This includes transitional and intertidal areas, salt marshes, wetlands, and beaches.

The zone extends, in Great Lakes waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of the U.S. territorial sea (three miles). The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Federal lands are excluded.

The act specifies that a State management program must include a definition of coastal zone boundaries, a list of areas of particular concern along with a list of priority uses within those areas, a proposed governmental structure for administering the program, and a method for controlling land and water uses within the coastal zone. Three types of controls are specified in the act: (1) direct regulation by the State; (2) local regulation consistent with State established standards; and (3) local regulation subject to State review.

In addition to providing for a review and approval process of State programs by the Secretary of Commerce, the act establishes a 15-member national advisory committee. The committee as a group is to possess "a broad range of experience and knowledge relating to problems involving management, use, conservation, protection, and development of coastal zone resources."

Congress envisioned a two-stage grant program for the development and operation of a State's coastal zone management program. Up to $9 million annually is authorized in the legislation for development grants and up to $30 million annually for administrative grants. They are to be granted on a two-thirds Federal/one-third State matching basis. The act also authorizes $6 million for the acquisition of estuarine sanctuaries as "natural field laboratories" on an even matching basis. Funds for the grants to States have not been appropriated.

Implementation: Within the Department of Commerce, the National Oceanic and Atmospheric Administration (NOAA) has the responsibility for administering the Coastal Zone Management Act. A coastal zone management task force has been established to begin planning

for implementation of the program and has undertaken four major tasks. The first involves the development of guidelines and regulations necessary for administration of the grants program. At the time of this writing, the guidelines are starting a round of informal review and comment within the Federal government, with publication in draft form in the Federal Register expected to follow. Every effort has been made to insure that these guidelines provide adequate direction to the States while remaining flexible enough to allow for differing State situations and needs.

The second activity is that of coordination with other Federal agencies active in the coastal zone, including the Department of the Interior, Environmental Protection Agency, Army Corps of Engineers, Department of Housing and Urban Development, the Coast Guard, and others. By forming working relationships with these agencies, the staff hopes to identify areas of duplicated effort at the Federal level and coordinate them in order to bring the full resources of the Federal Government to the States. The act itself was written with an awareness that land use legislation might be forthcoming and it delineates a coordinated approval process with the Secretary of Commerce and the official designated to administer any land use program.

The third function now being undertaken is an inventory of coastal zone management activities of the individual States and territories. The staff is examining and cataloging legislation adopted or under discussion in each State as well as the State structure that will administer such legislation.

Finally, recognizing that a strong bank of technical information is the backbone of any decision-making process, the staff is examining the technical aspects of the coastal zone management problem, in an attempt to better define the needs of a coastal manager. Efforts are being made to identify what kinds of research and information a coastal zone manager needs. For example, a manager very likely will need to know much more about estuarine and coastal water circulation, the waste assimilation capabilities of the coastal waters, and the specifics of coastal sediment transport before he can rationally manage the coastal zone with long-range success. Some of the required information may already be available to a coastal zone manager through universities participating in NOAA's Sea Grant Program, or research supported by other Federal agencies or through the private sector. The coastal zone management staff will work to identify informational gaps and to facilitate the dissemination of information already available but not yet in the hands of the coastal zone manager.

In the coming years, the demands upon our national coastlines will increase in scope and intensity. There will be insistent voices calling for faster or slower decisions on matters of development, conservation and preservation.

Ideally, of course, we would like to see decisions regarding the use of our coastal lands and waters made in full knowledge of the consequences. But we all realize that some actions cannot be deferred pending perfect information. If these decisions are not to be *ad hoc,* not submissive to the highest bidder nor to the loudest voice, then some means must be developed to bring the best available information to bear within a coherent system for decision-making; where responsibilities are well defined, and where the public interest is paramount.

The program will be concerned with coastal waters and the "land thereunder" to the 3-mile outer limit of the U.S. territorial sea, and to the international boundary in Great Lakes waters.

The relationship between States and the Federal Government that is now developing in coastal affairs certainly seems to have the potential for establishing that basic system. Hopefully, this cooperative relationship will expand in the future, nurtured by good will and common objectives. ■

Municipal and industrial users with contract storage of water may be lulled into thinking that future dry years are a thing of the past. But laws of many States offer questionable protection for conveyance of such waters down public streams.

Meandering Rights for Contracted Water

by William R. Walker
and William E. Cox

Anxiety over future water shortages is subtly settling in on many American municipalities. Faced with expanding industralization and steady population growth, they have gnawing doubts about satisfying tomorrow's water needs.

As a Nation, we have always believed in conserving water for future use in our reservoirs and today legislation exists that permits municipal and industrial water users to share in the storage capacity of Federal reservoirs. On the surface, this legislation may give the impression that the process of water supply storage has been simplified to the signing of a Federal contract, with the actual use of the water to be accomplished by asking for its release from the reservoir for subsequent diversion at a downstream location. In short, potential users may be lulled into thinking that concerns over future dry years are a thing of the past.

There are reasons, however, why this simplified view may not be valid in practice. One important factor is that the enabling legislation does not remove the burden of water rights acquisition from the contracting party in all situations. Another potential impediment concerns the use of natural stream channels to convey stored water to its ultimate place of use. Although this means of conveyance may be dictated by economic considerations, the added water released at the reservoir may reach the intended user only after being reduced in quantity and/or quality. The problem is that in some States water users located between the points of release and diversion have every right to continue using that stream also. Thus, upstream industries, irrigators, recreational users, and others might have the first right to use the released water.

It is assumed that municipalities and others contracting for water are aware of the pitfalls of water rights and would expect to defend priorities in the use of water as the need arises. However, since each State determines its own water law, interpretations vary over the relative rights of other users and the party contracting for water storage with a Federal agency. In places where conditions are ripe for conflict, it is a matter that could be scrutinized more objectively now before the conflict develops.

Despite the best of intentions at both Federal and State levels, the concept of storing water for future needs does not fit smoothly into the traditional division of authority

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Oklahoma City must bring its contract water through 123 miles of natural channel along the Beaver River. Water rights existing above and below the city's point of diversion have never been inventoried.

familiar to all students of law; States are the repositories for all powers not specifically delegated to the Federal Government. The line of demarcation between Federal and State jurisdiction over water rights is somewhat jagged.

Federal Involvement

Examples of Federal participation in this business of water supply storage date back to early times in the Nation's history. Perhaps the first example of such legislation was a congressional act of May 25, 1832, that authorized the Corps of Engineers to make certain improvements to Pennsylvania Avenue in Washington, D.C., and to supply certain public buildings with water. This act authorized the construction of storage reservoirs and a water distribution system. It also provided for the purchase of necessary water rights. This and other early legislation authorizing water supply storage by the Corps was in the form of individual congressional acts for each project.

Meanwhile, other legislation authorized the Bureau of Reclamation in the Department of the Interior to engage in storage activities in the western portions of our country. The first such authorization was passed in 1906 as an amendment to the Reclamation Act of 1902. This amendment authorized the Secretary of the Interior to withdraw public lands for use as townsites and to provide necessary water rights.

A 1920 provision added to the reclamation law authorized the use of waters for "miscellaneous purposes," but only when these purposes didn't interfere with other water rights, such as irrigation.

Nineteen years later the Reclamation Project Act of 1939 authorized Interior to actually enter into contracts with municipalities seeking a public water supply. However, this act also made it clear that irrigation projects still constituted a priority use of water in the western part of the country.

Passage of the 1956 amendments to the Watershed Protection and Flood Prevention Act removed the restriction that water resource projects authorized by the act would be limited to agricultural purposes. An accompanying House of Representatives Report specifically interpreted these amendments as authorization for water supply storage.

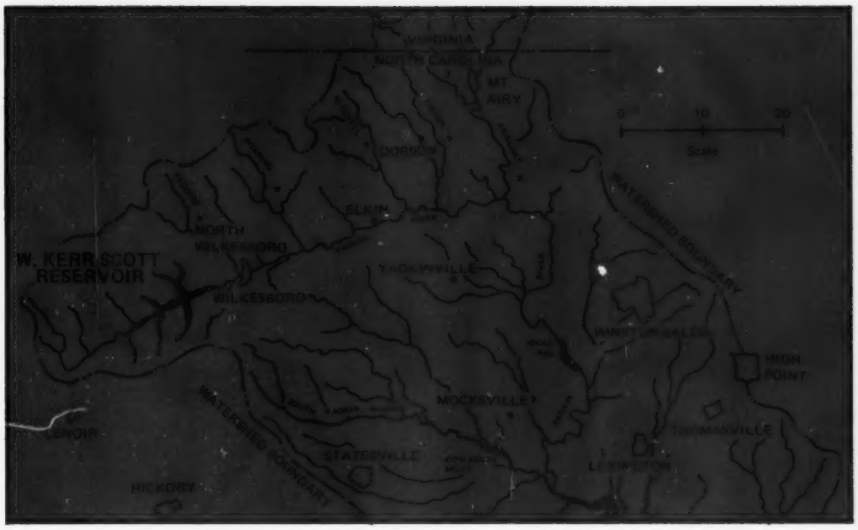
Blanket authority for the Corps of Engineers and Bureau of Reclamation to include water supply storage in their reservoir projects finally came into being with passage of the Water Supply Act of 1958. However, this act does not make provisions for acquiring water rights related to storage and does not guarantee the rights of the contracting party to use the stored water for its intended purpose. In fact, one of the subsections in this act reinforces older legislation that specifically protects any individual water rights spelled out under State law, rights which might be invoked in opposition to the storer's rights.

Water Law Doctrines

Whether the water rights of your city, local industries, nearby farms and ranches, recreation sites or your individual property would be honored at some future date will depend on your own State's water law. Although the water law of each State is somewhat unique, there are certain generalities which exist because of our fundamental reliance on two basic water law doctrines.

Under the *riparian* doctrine, water rights arise through the ownership of property which *borders or is traversed* by a natural body of water. All riparian owners have certain rights to use such water. The exact limit of this right varies from State to State, but a riparian owner

Lake Texoma water is 13 natural-channel miles from the contract city of Denison, Tex., and even longer distances from downstream industrial sites of contract purchasers Texas Power & Light Co., Sinclair Oil & Gas Co. and Texaco, Inc. The Red River Authority of Texas also stores its contract water supplies here.



W. Kerr Scott Reservoir utilizes 95 miles of the Yadkin River's natural channel to serve Winston-Salem, N.C., with contract water. Other communities and private water users drawing from the main channel and its numerous tributaries may share the right to divert the river's artifically augmented flows for their own supply.

generally can make a *reasonable* use of the water. Interpreting reasonableness, though, is not an easy task. Being relative, its interpretation always depends on the circumstances.

The *appropriation* doctrine predominates in 17 of our Western States where water rights are less likely to depend on ownership of riparian land than holding a State permit to apply the water to a *beneficial use*, such as irrigation or placer mining. In some of these Western States, however, appropriated water may be tied to specific parcels of land, but these parcels need not be riparian. Unlike riparian rights, which are equal among all adjoining riparian owners, the first appropriation right established on a stream has preference.

There is also an order of preference among different types of water uses in some States applying the appropriation doctrine. Thus, a municipality with a preferred water use could condemn prior appropriations held by users with a lower preference, with the costs of condemning those rights limited to their market value.

Acquisition of Storage Rights

In the Western States, the municipality of industrial water user desiring storage in Corps of Engineers or Soil Conservation Service projects is confronted with the problem of securing the necessary water rights through the framework of appropriative law. Since appropriative law usually requires fulfillment of an administrative permit procedure prior to the use of water, the possibility of participating in Federal projects without the necessary rights would be slight. However, if State law permits the condemnation of water rights of a lower order of preference at a future date, participation without prior possession of the necessary water rights would be encouraged. It does not appear that the right to condemn for future uses is a widely accepted element of the appropriative doctrine.

Storage in Bureau of Reclamation projects provides another alternative for the municipal or industrial water user in the Western States. Although section 7 of the Reclamation Act of 1902 permits the Bureau to acquire water rights for storage in their own projects, section 8 of the same act instructs the Bureau to conform with existing State laws. This section has been interpreted by the Supreme Court to mean that *acquisition* of water rights must be in compliance with State law but that State law cannot be asserted to control the *operation* of reclamation projects. Although "operational" aspects of a project have never been clearly defined, decisions have been reached regarding individual fact situations. For example, it has been held that a Federal restriction on the size of lands to be irrigated by reclamation project water is a binding regulation to be followed in the operation of a project *regardless* of State law concerning this issue.[1]

The exact role of State law relative to the acquisition of water rights may have been established in a later case where the Court suggested that such law be limited to the definition of the compensable interests held in the water.[2] This holding suggests that project purposes would not be subject to State approval.

This interpretation concerning the impact of State law creates the possibility of using Bureau projects for storage purposes not usually sanctioned under State law since the Federal Government can acquire storage rights without regard for that water's future use. Thus, the municipality or industrial water user contracting for storage in a Bureau project appears to be in a favorable position relative to the user contracting for storage in Corps of Engineers or Soil Conservation Service projects. Acquisition of water rights is an individual responsibility of the contractor in Corps or Soil Conservation projects. Therefore, the water rights are completely subject to any restrictions contained in the State law that applies to each location.

Neither have water supply storage rights been defined completely in riparian jurisdictions, where several potential obstacles exist. In the case of municipal use, it

[1] *Ivanhoe Irrigation District v. McCracken*, 357 U.S. 275 (1958).
[2] *City of Fresno v. California*, 372 U.S. 627, (1963).

These uses of water can become highly competitive during dry years, pointing up the need to refine water rights law during periods of plenty when deliberation can be more rational.

has been held that a municipality may use the water of a navigable stream for supply purposes, but it is generally accepted that municipal use is not a riparian right on nonnavigable streams. In addition, the rights to create storage for future use are generally more limited than the rights to make immediate use of the water for those same purposes. Furthermore, not every potential user is necessarily riparian to the water source, a prerequisite for the existence of a valid water right. Thus, a number of questions may exist regarding the theoretical legal basis of water supply storage in any given case.

However, it must be remembered that water rights under the riparian doctrine are defined through litigation arising out of conflicts between water users and not by grant from the State. Since the riparian doctrine requires a showing of injury in order for a legal action to be sustained, water supply storage would be possible in any situation where no damage to other riparians occurs *regardless* of whether a theoretical water right exists.

While this aspect of the riparian doctrine makes storage without possession of water rights possible, it does not remove the potential for a later legal action in the event damages are produced. The ability to condemn the necessary rights should an adverse judgment be entered makes participation in Federal projects without water rights feasible for municipalities; but the risk of injunctive relief to the injured party would make the advisability of such participation highly questionable in the case of most industrial users.

Conveyance of Stored Water

Acquiring water rights for storage purposes would not necessarily guarantee the quantity and quality of the stored water once it left a Federal reservoir. If the reservoir is many miles upstream from the purchasing municipality or industry, it is possible that artificial conduits would not be an economically feasible alternative to using the natural stream channel. Under State law, intervening water rights to any water flowing in a natural stream may exist. The longer the distance between the reservoir and place of use, the larger the number of likely water rights existing along that stream.

If all the riparian owners located between the release point at the reservoir and the diversion point downstream have the right to make a reasonable use of the added water along with that stream's natural flow, both quantity and quality could be affected adversely. In fact, the riparian doctrine recognizes that some reduction in both will occur as a normal consequence of reasonable use by intervening riparian landowners.

Problems associated with the conveyance of water through natural stream channels is not as serious in the Western States, since this concept of conveyance is recognized there both by the common law and through statutory enactments such as these excerpts from the laws of Colorado and Kansas, respectively:

> The owners of any reservoir may conduct the water legally stored therein onto and along any of the natural streams of the State, but not so as to raise the waters thereof above ordinary high watermark, and may take the same out again at any point desired with

due regard to the prior or subsequent rights of others to other waters in said natural streams. Due allowance shall be made for evaporation and other losses from natural causes for the protection of all rights to the waters flowing in said streams, such losses to be determined by the State engineer.[3]

(I)t shall be unlawful . . . for any person without an agreement with the State of Kansas to divert or take any water that has been released from storage under authority of the State of Kansas or that has been released from storage pursuant to an agreement between the State and Federal government . . .[4]

These statutes are silent with respect to the preservation of quality, whose control has become a subject of nationwide concern presently regulated by the Federal Water Pollution Control Act Amendments of 1972. This well known piece of recent legislation establishes a national goal of no pollutant discharges into streams by the year 1985. Thus, under this current Federal legislation, only 12 more years are available during which the capacity of our streams to assimilate pollutants from point sources can be used. It is during this same period that many municipalities and industrial establishments will begin to utilize the water supply contracts introduced in the 1958 Water Supply Act.

Recommendations

Since very few of the potential contractors have actually begun using stored water, many of the corrective measures are likely to be more politically acceptable now than when specific problems have arisen and conflicting positions have solidified.

One of the legal points that could be reviewed at this time is the amount of State statutory protection now in existence covering conveyance of stored water through natural stream channels without interference from other water users on the same stream. Without this protection, releases of stored water into natural streams could sustain both diminution in quantity and a degradation in quality. Permitting reductions in quantity and quality would erode the potential municipal or industrial contractor's investment in water rights and storage facilities. Except for those users in close proximity to the storage reservoir, artificial conduits may not be economically feasible.

The legislative history of the Water Supply Act of 1958 suggests that the authors were concerned with maintaining some State control over water use, but there is no direct statement to this effect in the act itself. Reference in the statute to prior legislation relative to the effect of State law does not clarify the issue.

Water rights associated with the storage of a water supply in those States operating under riparian law are not defined clearly and can only be ascertained by litigation. The resulting uncertainty imposes a burden on parties contracting for storage in Federal reservoirs where the contractors are required to acquire the water rights related to such storage.

An alternative to this uncertainty would be to let the Federal Government acquire the necessary water rights for storage in Federal reservoirs, passing on the added cost to the user along with or in the same manner as construction costs are handled. Then all parties claiming injury to their rights could present their claims against the United States. A prescribed time limit for presenting such claims would eliminate the uncertainty of new or expanded claims arising after extended periods of time.

Another alternative would be to let the water rights acquisition remain the responsibility of the user, but with the States taking action to remove some of the uncertainty concerning storage rights. In riparian States, a statute could declare that storage of flood or any other unused water for future supply purposes would be a lawful water use whenever the storage did not interfere with the rights of others. This right could be made available to riparians and nonriparians alike, thereby spurring local participation in Federal reservoir projects.

Municipalities in the Western States also need a clear means of obtaining water rights for anticipated future use under the appropriation doctrine. Such arrangement for future use could still permit others to make maximum use of the water involved on a temporary basis until such time as the municipal appropriator actually needed the water.

Industrial and municipal water users should also consider the possibility of obtaining storage rights in private hydroelectric projects. A recent amendment to the Federal Water Power Act authorizes the Federal Power Commission, under certain conditions, to license parts of such private projects for water uses other than power generation. Whether or not the Commission can also license surplus water from Federal dams is open to interpretation of the Federal Power Act.

These recommendations should be considered in connection with those concerning water supply storage voiced by the National Water Commission in its proposed report to the President and Congress.[5] Even though the Commission's recommendations are primarily concerned with policy issues and coordination of water supply activities, rather than the operational problems discussed here, efficiency dictates joint consideration of all shortcomings connected with the existing situation.

In summary, more effective use of our national water resources should not be stymied by ignorance and neglect of applicable Federal and State laws *and their interactions*. We should not delay a review of the current status of water rights relative to water supply storage. It will be too late once the need to compete for a limited supply of water for a burgeoning industrialized population is upon us. A crisis situation can destroy the climate of rationality so necessary for proper interpretation of our water related legislation. ■

[3]*Colo. Rev. Stat. Ann.*, sec. 148-5-2.
[4]*Kan. Stat. Ann.*, sec. 82 a-706b.

[5]National Water Commission, *Review Draft, Proposed Report*, Nov., 1972, pp. 5-83 through 5-102.

Events, Deeds & Deliberations

Demise of a Dam

With the push of a switch and the sound of a blast, the beginning of the end came about this past winter for the 45-year-old Washington Water Power Dam located on the Clearwater River at Lewiston, Idaho. The demise of the dam is the culmination of six years effort by the Corps of Engineers, Potlatch Forests, Inc. and the Washington Water Power Company. The first four spillway sections are to be removed this spring with the remaining sections to be removed by the summer.

The power company's dam would be rendered obsolete in 1975 upon completion by the Corps of Lower Granite Lock and Dam downstream. Water backed up in the new pool against the power company's dam would cause it to lose about 12 feet of hydraulic head. The resulting shorter fall of water would seriously impair the dam's power generating efficiency.

The removal of the power company's dam will restore about five miles of free-flowing river at the upper end of the old pool.

Many local, State and Federal agencies, besides the Corps, were involved in approving the removal of the dam. Agencies coordinating in the effort included the Environmental Protection Agency, the Federal Power Commission, U.S. Fish and Wildlife Service, the Idaho Departments of Fish and Game, Water Administration and Public Health. The City of Lewiston and Nez Perce County were also consulted.

The power company received $2.7 million for the land and facility, with Potlatch Forests paying $1.2 million and the Corps $1.5 million. Property acquired by the Corps along the shorelines of the Washington Water Power dam reservoir are being reserved for special uses. The Corps plans to make use of the property for fish and wildlife reserves and public recreation areas.

Blast knocks out first section of a dam.

River Flow Clocked

These record breakers may never make the Olympics, but a team of Brazilian and U.S. hydrologists holds the world's record for measuring the largest river flow. They clocked the Amazon.

By using a new technique involving measurements from a moving boat rather than at fixed stations, they determined the rate of flow to be four billion gallons per minute.

The measurement was made about 400 miles upstream from the mouth at the river's narrowest part, a little over one-and-a-half miles wide and 235 feet deep.

The average flow of the Amazon is about 10 times that of the Mississippi. The Amazon accounts for about 15 percent of all fresh water discharged into the oceans by all the rivers of the world.

A Backyard Water Lab

Students at Garden City High School, New York, have a water laboratory, so to speak, in their own backyard.

Some of the students are engaged in biweekly samplings of waters and sediments from Manhasset Bay, Hempstead Harbor and Shinnecock Inlet. Others collect samples from various coastal areas in New York such as Fire Island, Jones Beach and Coney Island to facilitate the study of waves, currents and tidal actions. They note the mineral variations in different localities and correlate the presence of microscopic shells in their samples with normal and abnormal ecological conditions.

Soundoff for Fish

Canadian researchers are trying to find a sound wave that will irritate the swim-bladders of fish so that they will stay clear of generating station intakes. The sound waves could also be used to repel alewives from park beaches.

Another possible result could be a method for using sound to take fish censuses, since various sizes of swim-bladders reflect sound differently. The study is a joint project of Ontario Hydro and the Ontario Ministry of Natural Resources.

Memory for Taste

"Fish produced in today's hatcheries are healthier, more vigorous, cost less and taste better than fish raised 15 or 20 years ago," an official of a wildlife resources office claims.

Biologists say hatchery-raised fish are better than ever, largely because of improved modern fish food.

Abysmal Ignorance?

The Sport Fishing Institute questions introduction of the exotic *grass carp,* also known as the white amur, into United States waters as a possible means of aquatic vegetation control. The Institute bases its case on the claim that there is "abysmal ecological ignorance" of the species. The Missouri Conservation Commission officially prohibits its release in that State.

Grass Treated Water

Tests show that common bermuda grass may be an effective tool for preventing aquifer pollution in artificial groundwater recharge.

An experimental study being conducted in Arizona jointly by the Agriculture Research Service, Environmental Protection Agency, and the Salt River Irrigation District has shown that effluent from a nearby sewage plant, loaded with ammonium compounds and coliform bacteria, is as pure as the groundwater in any unpolluted formation after passing through basins lined with bermuda grass.

Results thus far indicate that an acre of plant-soil filter can purify about 120,000 cubic feet of sewage effluent a year. At that rate, a 1000-acre site could process the sewage effluent of a metropolitan area with a population of close to a million.

Modeling for the San Francisco Bay

Effects of proposed manmade changes on the water quality in the San Francisco Bay-Delta area are being simulated at this Corps of Engineers constructed hydraulic model in Sausalito.

Tapping the Geothermal Brines

After further developmental testing of its geothermal well in the Imperial Valley of southern California, the Bureau of Reclamation will conduct research in desalting the geothermal brines.

The well is 8,030 feet deep and lined with 9 5/8 inch pipe to a depth of 7,262 feet. The last lined section has a 7-inch diameter casing where the maximum recorded temperature is 365 degrees Fahrenheit.

Maritime Nations Restrict Ocean Dumping

International restrictions on ocean dumping have been agreed to by the United States and 90 other maritime nations under a draft convention that would prohibit the discharge of some materials and strictly control others.

The agreement was negotiated in London recently under the sponsorship of the United Nations. This convention was an outgrowth of the U.N. Conference on the Human Environment held in Stockholm last June.

Substances to be banned by the agreement include organo-halogens, crude oil, nonbiodegradable plastics, highly radioactive materials and cadmium, mercury and their compounds.

A specific permit will be required for ocean disposal of materials requiring special care. These include cyanide and fluoride waste, heavy metals and bulky items that could impede navigation.

General permits will be needed for disposal of all other wastes, regardless of their impact on the aquatic environment.

In granting dumping permits, the nations agreed to consider quantity, toxicity, solubility, persistence, and potential harm to aquatic resources. Other factors on which permits will hinge include dumping sites, method of deposit and availability of alternative treatment methods.

Enforcement will be the responsibility of each nation. International inspection and policing is not provided. Each signatory agreed to "take measures in its territory to prevent and punish conduct in contravention of the provision" of the agreement. Procedures for assessing liability and settling disputes will be established at a future meeting.

One major issue left unresolved: how far out to sea a nation's territorial limits extend.

The convention is to become effective when ratified by 15 member nations.

Laser Beam Wilt

Water hyacinth and other undesirable plants have long choked southern streams, growing almost unchecked despite all efforts to curb them. Now there is a new method, laser beam eradication, that has been invented by Dr. Ralph Scott, a former Corps of Engineers scientist.

The treatment wilts the plants almost immediately and within eight weeks they are completely destroyed.

Dr. Scott's invention utilizes the laser energy for selective eradication of plant life in water as well as on land. He said that by selection on the proper level of laser beam energy, weed control may be affected for land plants, such as those found along the highway and railroad right-of-ways. The problem of air and water pollution is alleviated, since no chemicals are released into the environment.

Perhaps laser shooting will be a better deal than chemicals, mechanical harvest or biological controls.

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BOUND BOOK

Entrance to Bratsk and a sister hydroelectric power station complex at Ust-Ilim. *See page 17.*